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LETTER DISCRIMINABILITY WITH VISUALLY TEXTURED VERSUS PLAIN WHITE BACKGROUNDS

by

(C) JOSEPH W. WILCOX

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

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OF MASTER OF SCIENCE

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Date 11th April, 1979

Abstract

Visual texture is introduced as a potential source of information regarding properties of objects embedded in or superimposed upon a surface, and is discussed as a possible aid to discrimination of Roman alphabet letters. A "textured alphabet" is discussed in terms of two models: as a synthesis of the ideographic and phonetic modes of representing language visually, and in terms of E.J. Gibson's "distinctive feature" hypothesis. Twenty-eight kindergarten children divided into low and high reading-readiness groups, were exposed to three different "alphabets" in a simultaneous "same-different" task of discriminating single letters, as well as letter pairs. Error and latency data revealed the superiority of the high readiness group on the task, but failed to demonstrate differences between the "textured" and standard alphabets. One significant difference was found, a posteriori, between data for upper-case vs. lower-case letter stimuli, though this factor was confounded with sessions. Significant overall differences were found between correct "same" and "different" response latencies. These results are discussed in terms of various hypotheses of the nature of reading disabilities, and in the light of results of followup studies comparing the effects of three different alphabets on discrimination of successively presented letter groups by learning disabled children. Additional research needs are outlined, with recommendations for methodological changes.

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Introduction

The Problem in Brief

A large number of children experience difficulty in learning to read. This is true regardless of the label attached to them ("dyslexic," "reading retarded," "word blind," "reading disabled," etc.), and regardless of the supposed etiology (Gibson & Levin, 1975, pp. 485-486). Though reading problems may appear at various stages in learning to read--from decoding and letter recognition through word recognition and comprehension--Fries (1964) has stated that

> it is essential to reading at the very beginning that pupils have already developed such an ability to identify and distinguish the graphic shapes of letters as can be shown by instant and automatic responses of recognition. (p. 125)

It will be argued that, because visual texture in two dimensions is capable of providing usable information regarding objects represented in or on a surface (Gibson, 1950), visually textured backgrounds matched with Roman alphabet letters might provide a means of facilitating such "instant and automatic responses of recognition" of graphic materials, particularly for children who are as yet unskilled in making such responses. More specifically, in a forced-choice discrimination task, it is proposed that kindergarten pupils will respond more rapidly and more accurately to stimuli from a "textured alphabet" than they will to stimuli from the standard Roman alphabet.

Research from various areas in psychology and education bears directly on these questions, and requires discussion prior to a more detailed report of the present research. Questions which must be addressed here are: (a) to what extent can visual texture serve as a source of useful information; (b) what are the roles of letter perception and discrimination in the reading process, and (c) what established theoretical models of the visual expression of language may be applicable to a "textured alphabet."

Visual Texture as an Information Source

Visual texture and the theory of representation of space. Many of the tests of visual texture as an information source have involved description of the orientation of surfaces. J.J. Gibson (1950) virtually identified surface perception with the processing of texture: "the general condition for the perception of a surface is the type of ordinal stimulation which yields texture" (p. 76). The view he developed was that all information is contained in the stimulus array. He treated texture gradients as the primary media for conveying characteristics of physical substances, as well as "the impression of continuous distance on a surface" (p. 86). A gradient was defined as a serial change in the length of repetitive cycles of surface units, which "determine an array of light reflections from the surface which can be

focused as an image" (p. 78). Thus, perception of the object characteristics of surfaces was considered largely dependent upon the organism's ability to perform textural analysis.

Some criticisms have been levied against the Gibsonian view, however. While they do not bear directly upon use of texture to enhance letter discrimination, these criticisms do raise issues concerning the value of the concept of texture as an information source. E.G. Boring (1952), in particular, has objected to Gibson's formulations on the grounds that

> Gibson is writing phenomenology and he tells us that we have a visual world which corresponds . . . to the rigid, Euclidian, natural, tape-measured world, and with but small exceptions for illusion and error. That is good phenomenology and natural history, but it is not the body of exact quantitative knowledge that we call science nowadays. (pp. 144-146)

Boring implies that Gibson's view of textural information is an example of "partially reduced perception," in which the "total complexity of clues" is reduced, in order to make the observer dependent upon isolated parameters of stimulation.

Gibson (1952) has answered Boring's criticism by invoking the concept of proximal stimulation. He asserts that proximal gradients of texture, disparity, and deformation are at least hypothetically capable of giving rise to an invariant of the perception of surface over distance transformations, just as Boring's "body of exact

quantitative knowledge that we call science" would have it for object perception in general.

Tests of Gibson's theory have been equivocal, as shown by two studies (Flock & Moscatelli, 1964; Kraft & Winnick, 1967). In different ways, both tested Gibson's notion of the salience of surface unit regularities in conveying spatial information about the surface. The former study required college students to match the slant of a palmboard to that of a stimulus board containing six textures varied as to the regularity of size, shape, and separation of their component units. Results of both a reference and a replication experiment clearly showed veridicality of slant judgments to be a direct function of surface-unit regularity. Mean regression coefficients between match and standard increased with increasing unit regularity; there was some indication that regularity of unit shape ("irregular shapes" and squares were used) affected slant judgments more than did regularity of unit size or unit separation, though no direct tests among the three dimensions were made. In a related paradigm, but one which also required Ss to make width judgments of textures and in which the experimenter adjusted the match until S stopped him, Kraft and Winnick (1967) also found errors in judgment to increase with textural irregularity. Two of their four textured surfaces were drawn directly from Gibson (1950); these provided both the greatest (for a "cane"

pattern of small, regularly alternated units) and the least (for a "splatter" pattern) veridical judgments of slant and width. Support was also found for what these authors termed the "shape/slant invariance hypothesis"--i.e., that decreases in slant judgment accuracy will be paralleled by reduced accuracy in the judgment of shape (p. 141).

Visual texture and the identity of objects in two dimensions. Long before its psychophysical investigation as a source of information concerning three-dimensional space, surface texture in two dimensions was manipulated by pictorial artists in order to capture the subtleties of three-dimensional contour, distance, and the tactile "feel" of objects. As technology allowed improvements in painterly technique, the way became open "for the painter to see and paint in terms of light reflected upon the surface of forms, instead of in terms of form alone" (Canaday, 1958, p. 21). Interestingly, this shift from edge to surface in representing the world pictorially has a correspondence in the scientific study of visual processing of objects. While early structuralist and gestaltist investigations focused on form perception in terms of contours and boundaries, what we might call "edge processing," post World War II research has been increasingly concerned with the properties of form-filled space as conveyed by patterns and surfaces which extend between boundaries (J.J. Gibson,

1950).

Scientific interest in surface texture was greatly stimulated by the widespread use of aerial photography during the wars of this century. Textural analysis became highly sophisticated and increasingly reliable, as trained photogrammetricians, operating on a definition of texture as "the composite appearance of an aggregate of unit features too small to be individually distinct" (Smith, 1943, p. 102), learned to codify textural arrays and use this information to discriminate, say, a tributary from a trench. It was found possible to make effective analysis using characteristics of the array such as grayness, granularity, or patterning in a black and white photograph.

A recent study has taken a closer look at the textural analysis of black and white photographs. Nelson and Vasold (1965), examining recognition time for common objects represented on two-dimensional surfaces, used black and white photographs printed as both positives and negatives. It was found that median recognition times were superior for the positive prints, and that this effect was greatest for more difficult objects, as determined by pilot work. Since the edge features of positive-negative pairs were identical, this increasing advantage of positive photos reflects a greater reliance on analysis of surface texture with more difficult recognitions.

The work of Bela Julesz (1971) represents an

interesting attempt to employ texture in the construction of objects in both two and three dimensions, using binocular viewing of textural anaglyphs in the latter case. Though Julesz' ideas are not closely related to reading problems per se, it is instructive to note that he finds two differentials of texture to be readily discriminable without training: average size, and average density of textural surface units.

Figures composed of texture. Studies of perception of patterns or figures embedded in surfaces have extended the issue of surface information yield into new paradigms. Experimentation dealing with figures composed from texture is relevant to the use of a visually "textured" alphabet with backgrounds composed of dots of varying density and size, such as that used by Clement (Note 1), and raises issues regarding letter discriminability changes with such an alphabet in comparison with those obtainable with the present, complex textured alphabet (see Appendix B for a direct test between the two alphabets).

Whether or not the distinction drawn by Richards and Polit (1974) between texture as "an attribute of a field having no components that appear enumerable" (pp. 155-156), and pattern as a function of periodic shifts in phase is accepted, most investigators of the phenomena of surface perception would agree with Julesz that "in order to encode a pattern such that the higher processes would be able to

cope with it, one has to be able to find clusters" (1971, p. 133). In an attempt to describe some of the simple rules which Julesz contends govern detection of such clusters, Santoro and Fender (1976) asked Ss to make a forced-choice as to whether a boundary contained in a 100 X 100 dot stochastic array appeared to be located in the vertical or horizontal plane. These boundaries arose between two 50 X 50 dot textures which were adjacent to one another, but opposites in terms of two of the following three visual dimensions: vertical, horizontal, and diagonal correlations of the luminance levels of adjacent dots. For example, a texture with positive horizontal, but negative diagonal correlations would be paired with one having negative horizontal, but positive diagonal, with the vertical correlation constant. The intra-dimensional correlations for each texture were either $\pm$ 0.333, with positive correlation indicating similar luminance of adjacent dots, and negative correlation giving "a fine salt-and-pepper or smoothed-out appearance since there would be continual switching of level from dot to dot" (p. 977).

Multidimensional scaling of the resulting error rates showed that perceived dissimilarity of the textures (i.e., veridical boundary perception) was due to weightings on granularity, vertical-horizontal connectivity, and diagonal connectivity, in decreasing order. "Granularity" was treated as an aggregate of the other connectivities: "the

extremes of the granularity axis are smoothness and clumpiness, with randomness at the approximate middle" (p. 979).

In an earlier study involving a similar paradigm, Green, Wolf, and White (1959) found that detection of the horizontal or vertical nature of multiple boundaries (bars in a 128 X 128 dot matrix) improved with increased exposure time up to one second and with the number of bars up to a limit of eight. Manipulation of dot size and dot separation produced more complex effects: when "grain," defined as the square root of the number of dots in the display, was held constant while dot separation was decreased by decreasing the overall area of the display, the denser displays yielded lower boundary-detection thresholds. Since visual angle in the range of two to twelve degrees was found not to affect detection thresholds when other variables were held constant, it is apparent that dot separation, or density of the pattern, is a salient variable in Julesz' "clustering" phenomena.

In contrast to the results of Green et al., Pickett (1967) found that subjects were able to label various textures as "coarse" or "even" with significantly shorter latencies for larger (50 X 50 and 120 X 120) than for smaller (20 X 20) dotted matrices. Task differences may explain the discrepancy, however, since Green et al.'s boundaries would be expected to become more distinct with

density increases, while Pickett varied density ("transitional probability") within each matrix size, thus yielding psychophysical gradients of the perception of "coarseness" across matrices. His latency data may therefore reflect a relative ease of processing with larger arrays, a conclusion which relies on a parallel model of information processing. At the least, according to Pickett, "we certainly should be suspect of the basic assumption that sample size controls response latency" (p. 168). He is speaking of sample size in terms of the number of surface units of texture per sample.

Figures superimposed upon textured surfaces. A few studies have explored the parameters governing emergence of a figure from a textured ground. At the level of theory, Pickett (1968) has proposed that "texture discrimination may be a basis for object and symbol identification by providing another dimension of contrast between figure and ground" (p. 7), and that "the perception of figures may be dependent on sensing departures from the typical structure of the background in which they are immersed" (p. 23). DeHirsch, Jansky, and Langford (1966), after reviewing the literature dealing with prediction of reading failure, conclude that "teaching the child to pull out the relevant figure from a strongly-structured ground promotes the organization of the visual field" (p. 89).

In an attempt to quantify the relationship between

textural variables and perception of a superimposed figure, Beck (1966) examined adults' ability to identify 35 letters and numerals (excluding zero) surrounded by checkerboard patterns varying as to size and number of units, under varied exposure times. His results indicate that improved symbol identification occurs with increases in surround size and increases in exposure time up to certain limits. Patterns that were either too small (e.g., only two enlarged squares) or too closely connected to the symbol contours tended to block symbol legibility. These results were viewed as reflecting a tendency of the visual system to "abstract the common elements of a pattern to form a ground" (p. 74), and the greater ease of such a process with larger surrounds. Using a much simplified visual array, one interpretable also as a study of contour perception, Weitzman (1963) determined discrimination thresholds for two gaps in the bottom contour of a black outlined square which was vertically bisected by an outline profile of a human face. Keeping subjects fixated at the center of the array by using an interposed reading task, and randomly switching the face's direction, he found that 24 of 29 adult Ss first discriminated the gap which appeared on the figural side of the array (i.e., on the side of the face). He concluded that the lowered threshold for accurate discrimination of the contours of a figure over its ground was due to the nature of the figure-ground dichotomy--i.e.,

a phenomenon inherent in the perceptual act of separating the two.

Letter Perception, Word Recognition, and Reading

Surprisingly little research in addition to Beck's (1966) has been devoted to the study of letters superimposed on textured backgrounds. However, Clement (Note 1) reports in an unpublished study that dotted textural backgrounds varying in dot size and dot density significantly lowered discrimination response latencies of cerebral-palsied children when compared to letters on standard (white) backgrounds. Unfortunately, his methodology is unclear; his data are given in Tables 1, 2 and 3. For the sake of clarity, Clement's dotted alphabet will hereafter be referred to as the textured alphabet, simple (TAS), while the experimental alphabet described in Appendix A will be termed the textured alphabet, complex (TAC).

In another study reported in the same document (Note 1), Clement had 24 children four to five years of age name words two to six letters in length. Half of the children were randomly assigned to a texture-letter condition, and half to a standard letter condition. Groups were instructed daily in classroom-type settings and tested weekly, instruction covering a six-week period (30 classroom days). While training involved emphasis on pronunciation and word

Table 1

Clement's (Note 1) ANOVA Summary, Alphabet Study with Cerebral-Palsied Children

Source	SS	DF	MS	F	P Less Than
Within Cells	23.267	72	0.323		
G	2.702	2	1.351	4.181	0.019
N	2.414	2	1.207	3.735	0.028
A	11.663	1	11.663	36.092	0.001
GN	0.281	4	0.070	0.217	0.927
GA	1.981	2	0.990	3.066	0.052
NA	0.935	2	0.487	1.448	0.241
GNA	0.349	4	0.087	0.270	0.895

Note. G denotes type of letter grouping (Stroke--Circle --Stroke X Circle)

N denotes number of letters in a stimulus (2--3--4)

A denotes type of alphabet (Regular or Surface)

Main effects of type of letter grouping, number of letters, and type of alphabet are all significant at .05 level. No interactions reach this level, though GXA is quite close. See Table 2 for means, as well as Newman-Keuls analyses indicating sources of these main effects. Data are mean response latencies in a "same-different" task of discriminating simultaneously displayed letter groups.

Table 2

Clement's (Note 1) Factors and Means, First Study

Factor						
G	1	1	1	1	1	1
N	1	1	2	2	3	3
A	1	2	1	2	1	2
Mean	1.599	1.180	1.960	1.279	2.019	1.299
Factor						
G	2	2	2	2	2	2
N	1	1	2	2	3	3
A	1	2	1	2	1	2
Mean	2.159	1.359	2.440	1.399	3.019	1.479
Factor						
G	3	3	3	3	3	3
N	1	1	2	2	3	3
A	1	2	1	2	1	2
Mean	1.679	1.579	2.099	1.419	2.319	1.819

Variable:

N_1 = Pairs of letters

N_2 = Trios of letters

N_3 = Quads of letters

G_1 = Stroke letters

G_2 = Circle letters

G_3 = Stroke-circle letters

A_1 = Standard Alphabet

A_2 = Surface Alphabet (TAS)

Note. Subjects were divided into three groups, one for each G factor, with 5 Ss in each group. Measures were repeated on N and A factors.

Table 3

Newman-Keuls Analyses of Clement's First Study Data

	N Factor		
	N_1 1.593	N_2 1.766	N_3 1.992
N_1 1.593	--	.173	.399*
N_2 1.766		--	.226
N_3 1.992			--
	G Factor		
	G_1 1.556	G_3 1.836	G_2 1.976
G_1 1.556	--	.28*	.42*
G_3 1.836		--	.14
G_2 1.976			--
	A Factor		
	A_2 1.424	A_1 2.144	
A_2 1.424	--	.72*	
A_1 2.144		--	

*denotes significance at .05 level.

Note. The Newman-Keuls analyses were performed by this author, not by Clement. They use only the factor means shown, as Clement's raw data were not available, and, therefore give only an indication of the sources of his main effects (see Table 1). See Table 2 for definitions of symbols.

meaning, tests required the child to select a given word from four choices (e.g., "which word is 'and'?"). Within each letter-condition, six children worked in the morning, and six in the afternoon; four different teachers were used, apparently without rotation. Results after the completion of all tests showed word-selection errors to be significantly lower for the dotted alphabet group than for the standard alphabet group (see Figure 1).

While there is still debate as to whether or not skilled readers continue to process words in a letter-by-letter fashion (Henderson, 1976) or move on to a "whole word" recognition method (Huey, 1908, pp. 100-101; Johnson, 1975), no one today seriously denies that the process of learning to read involves training in letter discrimination. It is unlikely that even the advocates of the "look and say" or the "word shape" methods of reading instruction would wholly deny this claim; purists in these methods have become a virtually extinct species.

It is commonplace to find letter discrimination at the top of a list of skills considered "critical" to reading (Gibson, Gibson, Pick, & Osser, 1962; Robeck & Wilson, 1974, p. 261), or named as a first phase in the reading process (E.J. Gibson, 1970a). By analyzing word-matching errors of kindergarten and first-grade children, Edelman (1963) found the salience of cues, in decreasing order, to be first letter, last letter, and word shape, with word shape running far

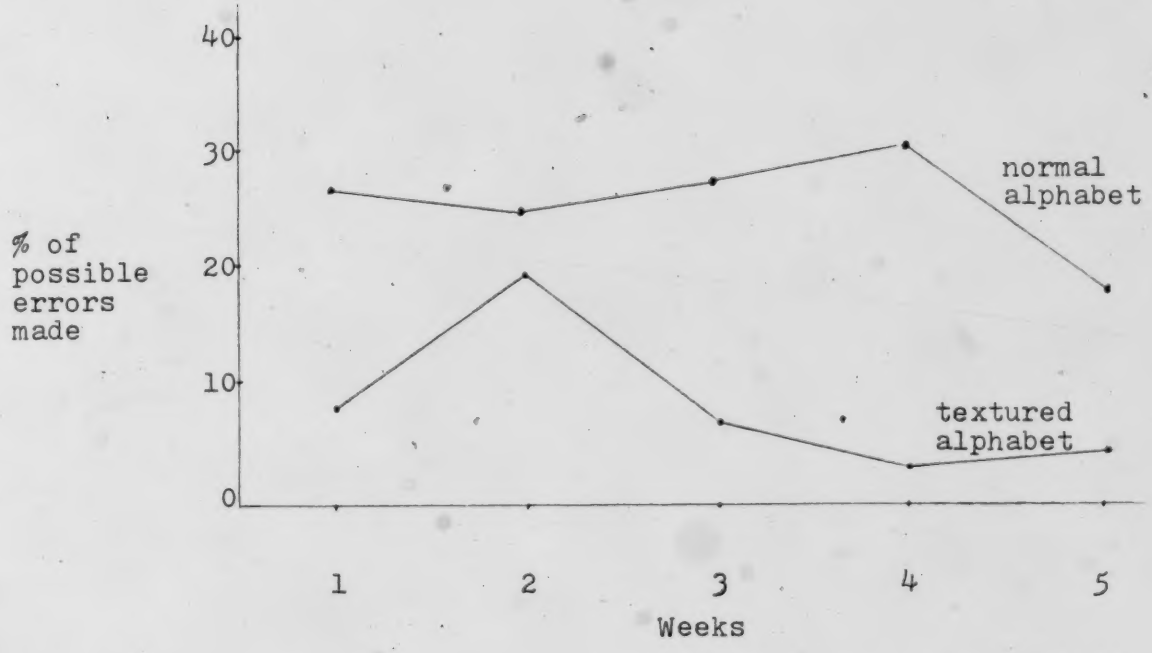

Figure 1. Clement's (Note 1) Error Data from Second Study

Error totals are plotted; there were 12 Ss in each alphabet group. Normal alphabet errors appear to average about 25%, while textured (TAS) alphabet errors appear to average only about 8%. Words were selected from four alternatives; the task was essentially word recognition in a transfer test following training in word recognition, meaning, and pronunciation.

behind. This does not imply that letter discrimination skills come naturally, however; as Biemiller (1970) has pointed out, children will avoid using graphic information as long as they can "get by" (the task in this case was oral reading) using contextual clues, or aural memory for familiar phrases.

Distinctive feature analysis of letters. What aspects of letter discrimination must be taught, and in what fashion, if reading problems are to be minimized? Eleanor Gibson's theoretical framework of "perceptual learning" may be invoked as one very influential response to this question. Briefly, her view is that invariant relations exist in the world of stimuli, and that the process of "perceptual learning" involves a gradual abstraction of "distinctive features" of objects, as instances of these invariances, from the available array. The human thus learns when to respond through a process of selectively attending to appropriate stimulus features, rather than through a process of association:

> Attaching the response to the right cue is a trivial matter; it is discovering the critical differentiating feature that accounts for differences in difficulty between . . . problems. (1969, p. 332)

Applied to the task of letter discrimination, this stance implies that helping the child to focus on the distinctive features of letters will facilitate progress in this early stage of reading. What are these features? Their criteria, according to E.J. Gibson, are that

> the differentiating features of letters must remain invariant under certain transformations (size, brightness, and perspective transformations and less easily described ones produced by different type faces and handwriting). They must therefore be relational, so that these transformations will not destroy them. (1970a, p. 317)

In a study of confusion errors of Roman capitals by four-year-olds, Gibson, Osser, Shiff, and Smith (1963) found that a feature list distinguishing between straight and curved, intersecting, discontinuous, and redundant (cyclical or symmetrical) strokes offered the best prediction of errors. Naus and Shillman (1976) offered a reinterpretation of distinctive features of letters based on "functional" rather than physical attributes, the former being "abstractions that are elements of the underlying representation of the character" (p. 394). Unfortunately their experimental example, the "leg" attribute distinguishing Y from V, does not adequately separate the "functional attribute" from the distinctive feature. E.J. Gibson might say that the "leg" is a distinctive feature for discriminating Y from V, but not for discriminating Z from S, for example. Thus, the "functional attribute" concept, in its present form, can be wholly subsumed under the distinctive feature hypothesis.

The child's task of learning letter features is complicated by the fact that certain transformations involving position--such as the orientation of a letter on a page of print--which would not alter the identity of natural objects, become critical to the identity of letter

forms (Gibson, Gibson, Pick & Osser, 1962; Nelson & Peoples, 1975). A "d" becomes a "p" or "b" or "q" depending on the nature of reorientation. Thus, some aspects of object identity must be unlearned, or at least amended, in order for the child to learn the distinctive features of letters. Developmental studies such as the two cited immediately above clearly indicate that letter reversals are prominent in kindergarten pupils, and gradually decrease with successful reading instruction. The Gibson et al. (1962) study, involving a non-delayed, match-to-standard task of "letter-like," but unfamiliar forms, further indicates that the decrease in line-to-curve errors is second only to the decrease in rotation-reversal errors between ages four and eight. In a study using simultaneous tachistoscopic presentation using only upper-case letter pairs and requiring a "same-different" response of undergraduate Ss, Clement and Carpenter (1970) found that visual similarity in terms of straight or curved stroke components remains a salient feature for all letter comparisons.

With at least some of the distinctive features of letters isolated, the question remains as to how these features might best be taught. E.J. Gibson's writings provide some general answers: "Methods of teaching that would promote efficient strategies of perceptual search and detection of invariant order should be a first concern in instructional programs" (1970b, p. 143). What might such methods be? "Discrimination should be facilitated when

distinctive features are enhanced in a stimulus display" (1969, p. 102), and "graphic units could be more discriminable at the expense [in terms of simplicity] of adding distinctive features to the basic array" (Gibson & Levin, p. 168). The relevance of these prescriptions for a teaching aid such as a visually textured alphabet, for example, is obvious: such an alphabet would add distinctive features to each letter, and might therefore enhance their mutual discriminability. This concept will be developed more fully in a later section on models for a textured alphabet.

Schema learning and letter discrimination. Despite the prominence of Gibson's ideas, letter perception probably does not depend wholly upon analysis of distinctive features. The concept of schema learning, or representation in memory of a prototype for certain stimuli, has also been invoked (Pick, 1965; Frith, 1974). Pick compared two groups of kindergarten children on a series of visual and tactile matching-to-standard tasks, employing the same "letter-like" stimuli used by Gibson et al. (1962). While one group was trained to discriminate three standard shapes and three transformations of each, then required to transfer to three additional transformations of the same standards ("schema" group), the other group was identically trained, but required to transfer the same three transformations to three new standards ("distinctive feature" group). Errors in simultaneous matching tasks showed superior performance

of the distinctive features group. However, no differences between groups were found in a successive, tactile matching task. Pick concluded that schema learning did therefore occur, but only on tasks requiring memorial operations, since differences disappeared in the successive condition.

Frith studied letter discrimination by embedding a reversed letter in a non-reversed matrix, and vice-versa. It was found that certain reversed letters are detected more rapidly as "odd" targets in a matrix composed mainly of the same letter in normal orientation, than are the same letters in a matrix dominated by their own mirror images. For example, "it takes approximately twice as long to find normal Ns among reversed Ns . . . as it takes to find reversed Ns among normal Ns" (p. 113). He termed this result a "reversed context effect." With adult Ss, the effect was present with upper-case Z, L, R, and C, and lower-case h and y, but not with upper-case S, D, or Q, nor with unrecognizable symbols. The effect also varied with the ratio of targets to non-targets in the overall array. Frith explained the effect in terms of conflict between the schema established by immediate context and a memorial schema of the letter, the flexibility of which could allow a reversed letter to be processed as a normal letter, but <u>not</u> vice-versa. Thus, with normal letters embedded in a reversed matrix, extra time was required to label the normal letters as "odd," since these letters matched the memorial,

but not the contextual schema. The absence of the effect with certain letters was ascribed to strategies which bypass schema by focusing on single features such as "leg position in a Q." An interaction of internal schema with distinctive feature analysis is again indicated, though Frith would differ with Pick's conclusion that schema operate only in memorial tasks.

Reicher, Snyder, and Richards (1976), while indifferent to the "internal schema" hypothesis, have nevertheless extended the generality of Frith's findings to letters rotated 180° in upright matrices (both vertical and horizontal rotation), letter-fragment targets in normal matrices, and "Gibson figures" (see above) in normal letter matrices. Interestingly, the effect persisted, but was no greater, when a mask intervened between matrix exposure and S's response. This result further erodes schema learning. In contrast, Gould and Peeples (1970) found that search time, errors, fixation number and fixation duration all depend more upon the physical characteristics of the standard pattern than upon its meaningfulness or pattern class (geometric pattern, symbol, or object) when these stimuli are mixed in an eight-item matrix. That is, relative familiarity of the standard and target items did not affect these variables, as it did in the studies of Pick (1965) and Frith (1974). Target patterns in the matrix were always fixated longer than non-target patterns,

regardless of whether the targets were geometric patterns, objects, or symbols. Some of the discrepancies may be due to the use of children in Pick's study vs. the use of college students and adults in the others. Differences might also be related to task differences such as a requirement for simple detection of target presence (Reicher et al.) vs. counting of targets (Gould & Peeples) vs. selection of targets from a pack of cards while allowing the subject to make constant reference to the symbol (Pick). Certainly no definitive test of distinctive feature theory vs. schema theory exists at this time, though Pick's study makes a good attempt, within the limited boundaries of her paradigm. Nor is it clear whether, or in what manner schema theories of letter discrimination might generate methods of letter-form instruction different from those which follow from the distinctive features approach.

Teaching letter names. Another instructional problem related to letter perception is touched upon in the debate over the efficacy of teaching letter names. Samuels (1972) has outlined the history of the problem, and attributes the current resurgence in letter-name training to causal imputations arising from correlational data which relate letter-name training to reading ability. In a training-transfer task, Samuels trained four groups of grade-four children to discriminate four artificial letters, which were highly unalphabet-like. The discrimination group learned to

associate a shape with each "letter," while the "name" group associated a verbal name; in the transfer task, subjects were required to pronounce four two-letter words formed from the artificial graphemes. No significant group differences appeared on the trials-to-criterion measure in the transfer task. Samuels therefore concluded that the efficacy of letter-name instruction had received no support. However, in a partial replication of this study (Chisholm & Knafle, 1978), which differed from Samuels' (1972) only in using "Gibson figures" rather than Samuels' artificial graphemes in training, the letter-name group performed significantly better than the letter-discrimination group on the transfer task. These authors note that Samuels' (1972) data showed a slight trend in favor of the name group, and attribute the greater significance in their results to the use of simpler figures in the training task. They also make the point that artificial alphabets bearing no physical resemblance to the Roman may be of limited value as indicators of normal classroom reading performance.

Two Models Applicable to a Textured Alphabet

This last-stated conclusion of Chisholm and Knafle may be at odds with research underlying the first of two models which will be outlined as potentially useful in predicting the effects of a textured alphabet. Nelson and Ladan (Note 2) presented pairs of Chinese characters, graded as to

visual complexity, to second-grade children of both "better" and "poorer" reading ability as measured by the Metropolitan tests of readiness and reading achievement. With a "same-different" task, the error scores successfully differentiated the two groups in both simultaneous and successive modes of presentation, though the absolute number of errors was much greater in the successive mode. In addition, Nelson and Ladan (1976) found that native English speakers with no knowledge of Chinese script were able to rate the meaningfulness of Chinese characters, on a zero to five, whole number scale, in a manner that correlated highly ($r = .92$, $p < .05$) with the ratings made by Chinese-speaking observers. That the English subjects did not simply rate on the basis of visual complexity as indexed by a stroke count of the characters is evidenced by the fact that their mean rating for compound, asymmetrical stimuli was lower than that for both symmetrical and asymmetrical simple characters. In the same vein, N. Ferguson (1975) found that the ability of five-year-olds to read symbols for words (i.e., to read logographs) is more predictive of later reading ability than are reading readiness scores in vocabulary, or in auditory and visual perception tasks.

Taken together, these results suggest that something about logographic or ideographic methods of representing language in script is communicated to both non-reading

children and to adults schooled to read an entirely phonetic alphabetic system (the standard Roman). One might then speculate what would happen to the discriminability of Roman characters if this "something" were added to the phonetic alphabet, producing an ideographic-phonetic system. This is the model which may be applied to a textured alphabet, with background visual textures introducing the ideographic component.

But the model needs specification. What might this communicable "something" in ideographic systems be? A closer look at the nature of such systems is warranted.

Firstly, terms must be defined. Havelock (1976), notes that

> between the measure of what words 'say' when they are spoken and their 'meaning' when they are written down there will always be a gap of some sort, of varying dimensions, depending on the script used. (p. 13)

He draws a distinction between truly ideographic systems, which symbolize concepts or thought directly, and logographic systems, in which "a sign represents a whole word, not its phonetic components" (p. 13). Lotz (1972) amplifies this distinction, writing that

> in considering logographic systems, the basic correlation is not between the logographic symbol and the individual sound unit . . . but rather between the morpheme, the minimal formal unit [of meaning], and the logogram . . . which corresponds to the entire semantic spectrum of the spoken unit. But the symbol has nothing to do with speech; it refers directly to the morpheme and its reference. (p. 118)

Thus, both writers classify Chinese script as a logographic

system, though it is certainly more "ideographic," in a generic sense, than is the Roman, wholly phonetic system. Havelock's discussion (p. 13) sheds further light on these distinctions. It may be fruitful, then, to think of Havelock's "gap" as existing primarily in the phonetic dimension for logographic script, and in the "semantic spectrum" dimension for alphabetic script. Carroll (1972) points out that "the problems of teaching the reading of an alphabetic system may not be very different from those of a nonalphabetic system" (p. 106). Perhaps this is precisely due to the need to narrow the "gaps" between spoken and written meaning in both systems.

We are now more able to identify the "something" which is communicated to English-speaking individuals by Chinese script. Because a single "sign" in Chinese may represent a word, and a "character," as a blend of signs, may consist of a series of "hyphenated" words (to borrow from Havelock), the purely perceptual unit (to an English observer) of the character can be said to contain "semantic features" which, while devoid of specific semantic content, still manage to convey the possibility of linguistic morphemes. Nelson and Ladan (Note 2) imply as much: "we therefore conclude that perceptual factors may plan an important role in the use of Chinese characters as intermediaries in introducing reading" (p. 9).

Thus, a model for the textured alphabet may be derived,

by way of analogy, from these studies. Gibson and Levin (1975) write that "the [Chinese] character may be analyzed into constituent elements, or features, in ways that are analogous to the features of letters or words" (p. 159, emphasis added). The model, then, is this: a series of Roman letters arranged into a "word" conveys a phonetic compound. When a texture is assigned to each letter, the letter-texture compound forms a "word-plus-a-sign," in a manner analogous to the way in which a Chinese character becomes a "meaning which each [sign] by itself would not convey" (Havelock, p. 13). Thus, a textured alphabet may help to narrow the "gap" inherent in an alphabetic system by providing a figural-perceptual component which, while not semantic in itself, creates a compound in which the morpheme(s) may be more readily communicated than they are in either "signs" or alphabetic "words" in isolation.

A second model, outlined above in the discussion of E.J. Gibson's distinctive features hypothesis, may be stated more succinctly. While letters already contain a number of features by which they may be reliably discriminated, certain children apparently either fail to learn what these features are, or fail to process them correctly, once learned. The textured alphabet may be modeled as a source of additional distinctive features for Roman alphabet letters, on a purely perceptual basis, since each Roman letter is permanently matched to a visually

patterned background. Features which are distinctive for the discrimination of the backgrounds (see Appendix A) may then be thought of as additive with those features which are distinctive for letter discrimination, providing a richer matrix of potentially significant information for making letter distinctions.

Obviously, the danger of information overload exists. Citing some support, Gibson (1969) cautions that "adding to the number of potentially useful cues may not in fact facilitate the learning of a simple discrimination task for young children" (p. 462). The question therefore becomes an empirical one, or rather a set of interrelated questions requiring experimental testing: how many distinctive cues can be added to letter forms before discriminability is inhibited rather than facilitated? What form must these cues (features) take in order to minimize inhibitory, and maximize facilitory effects? And, finally, how well does the form of the present "textured alphabet" approximate such an ideal form, both in terms of the manner chosen for adding these features (i.e., as backgrounds), and in terms of the specific patterns employed? While the present research cannot provide even tentative answers to all of these questions, it should provide explicit answers to some, as well as an empirical foundation on which the answers to the rest may eventually be constructed.

Thus, we have seen (a) that visual texture <u>can</u> serve

as a useful information source, at least in some contexts; (b) that the abilities to perceive letter contours and to make correct letter discriminations are typically considered fundamental skills in learning to read, and (c) that an alphabet composed of letters on visual textures may enhance letter discriminability, as such an alphabet is described by the two models given.

Hypotheses and Predictions

The scientific hypotheses, statistical hypotheses, and statistical predictions of this research are most readily presented in tabular form (Tables 4 & 5). Analyses to verify or refute the predictions, and thereby test the statistical hypotheses, will follow an overall analysis of variance (ANOVA) of the 3 X 2 design for each set of data, with repeated measures on the alphabets (3) factor. The ANOVAs will show whether or not the effects of alphabet type, group, or their interaction are significant for either of two sets of data, one set consisting of errors, the other of response latencies.

The theoretical rationale underlying scientific hypothesis 1 (see Tables 4 & 5), and its subsequent statistical hypotheses and predictions, is provided by research discussed in the introduction. To the extent that (a) visual texture can serve as a source of useful information, (b) that letter-by-letter analysis is essential in at least

Table 4

Hypotheses and Predictions

Scientific Hypotheses	Statistical Hypotheses		Statistical Predictions	
	For mean response latency per trial per S	For mean errors per trial per S	For mean responce latency per trial per S	For mean errors per trial per S
1) The textured alphabet will increase stimulus discriminability relative to both a standard alphabet and to backgrounds without letters.	1) (a) $H_0: \mu_2 \geq \mu_1$ $H_1: \mu_2 < \mu_1$	1) (c) $H_0: \mu_5 \geq \mu_4$ $H_1: \mu_5 < \mu_4$	1) (a) $\bar{X}_2 < \bar{X}_1$	(c) $\bar{X}_5 < \bar{X}_4$
	(b) $H_0: \mu_2 \geq \mu_3$ $H_1: \mu_2 < \mu_3$	(d) $H_0: \mu_5 \geq \mu_6$ $H_1: \mu_5 < \mu_6$	(b) $\bar{X}_2 < \bar{X}_3$	(d) $\bar{X}_5 < \bar{X}_6$
2) The increase in discriminability in 1) will be more pronounced for lower than for higher reading-readiness kindergarten pupils.	2) (a) $H_0: \mu_7 - \mu_8 = \mu_{10} - \mu_{11}$ $H_1: \mu_7 - \mu_8 \neq \mu_{10} - \mu_{11}$	2) (c) $H_0: \mu_{13} - \mu_{14} = \mu_{16} - \mu_{17}$ $H_1: \mu_{13} - \mu_{14} \neq \mu_{16} - \mu_{17}$	2) (a) $\bar{X}_7 - \bar{X}_8 > \bar{X}_{10} - \bar{X}_{11}$	(c) $\bar{X}_{13} - \bar{X}_{14} > \bar{X}_{16} - \bar{X}_{17}$
	(b) $H_0: \mu_9 - \mu_8 = \mu_{12} - \mu_{11}$ $H_1: \mu_9 - \mu_8 \neq \mu_{12} - \mu_{11}$	(d) $H_0: \mu_{15} - \mu_{14} = \mu_{18} - \mu_{17}$ $H_1: \mu_{15} - \mu_{14} \neq \mu_{18} - \mu_{17}$	(b) $\bar{X}_9 - \bar{X}_8 > \bar{X}_{12} - \bar{X}_{11}$	(d) $\bar{X}_{15} - \bar{X}_{14} > \bar{X}_{18} - \bar{X}_{17}$

Table 5

Definitions of Symbols for Table 4

u_1	= mean of mean response latency per trial to A_1 stimuli, population
u_2	= " " " " " " " " A_2 " "
u_3	= " " " " " " " " A_3 " "
u_4	= mean of mean errors per trial for A_1 stimuli, population
u_5	= " " " " " " " " A_2 " "
u_6	= " " " " " " " " A_3 " "
u_7	= mean of mean latency per trial to A_1 stimuli for low readiness pupils
u_8	= " " " " " " " " A_2 " " " " " "
u_9	= " " " " " " " " A_3 " " " " " "
u_{10}	= " " " " " " " " A_1 stimuli for high readiness pupils
u_{11}	= " " " " " " " " A_2 " " " " " "
u_{12}	= " " " " " " " " A_3 " " " " " "
u_{13}	= mean of mean errors per trial for A_1 stimuli for low readiness pupils
u_{14}	= " " " " " " " " A_2 " " " " " "
u_{15}	= " " " " " " " " A_3 " " " " " "
u_{16}	= " " " " " " " " A_1 stimuli for high readiness pupils
u_{17}	= " " " " " " " " A_2 " " " " " "
u_{18}	= " " " " " " " " A_3 " " " " " "

Note. All corresponding $\bar{X}$s in Table 4, Table 6, and text refer to sample means corresponding to the population values given above.

the early stages of learning to read, and (c) particularly to the extent that the "ideographic-phonetic" and/or "distinctive feature" models are applicable to a textured alphabet, such an alphabet would be extected to significantly enhance the discriminability of letter stimuli. The rationale for hypotheses and predictions 2, while obviously presupposing confirmation of hypothesis set 1, is provided, in addition, by research supporting the "perceptual deficit" hypothesis of reading disabilities. While a more thorough treatment of this hypothesis will be deferred to the discussion section of this paper, a basic introduction is appropriate at this time.

Zeaman and House (1963) have commented that low discrimination scores (or higher thresholds) demonstrated by retarded children in a number of studies probably do not reflect impaired learning ability so much as "low initial probability of observing certain relevant dimensions" (p. 188). They suggest that increasing the distinctiveness, or emphasizing the figural nature of the stimulus in relation to its background could aid such pupils in making simple discriminations. Silver and Hagin (1970), on the basis of a "marble test" for figure-ground and pattern perception skills of reading disabled children, conclude that "80% of children with reading disabilities have difficulty with the orientation of visual stimuli in space" (p. 448). That such deficits involve some inherent

perceptual problem is reinforced by the results of a 10-12 year followup study; individuals who were tested as children with reading disabilities still performed significantly worse than normal controls, on the same task, more than a decade later (p. 452).

A definitive summation of the perceptual deficit hypothesis of reading disability comes from Flax (1970):

> Many individuals who suffer from severe early reading deficiency, characterized by an inability to learn word recognition skills, suffer from deficiencies in visual form perception and inappropriate integration of vision with other senses. Much of the symptomatology of dyslexia is explainable in terms of inadequate visual performance. (p. 370)

To the extent, then, that children in the low reading-readiness group in the present study overlap or share common characteristics with the reading disabled groups discussed above, it is reasonable to suppose that a method such as a textured alphabet which is specifically designed to enhance visual-perceptual discriminability of letter stimuli may potentially benefit this group more than it will benefit the high-readiness pupils (hypothesis set 2). While the perceptual deficit hypothesis has not gone unchallenged (see Discussion), it has served as one of the principal descriptive foci for the literature on dyslexia (Robeck & Wilson, pp. 136-137).

Methods

Design of Experiment

Table 6 shows how sample means for this experiment will be mapped onto the overall 3 X 2 design by cells. While not shown in Table 6, the data examined will be mean errors (or latency) per trial per subject, due to the fact that the number of trials for A_3 is less than that for either A_1 or A_2. The repeated measures procedure will be used, rather than a factorial design with separate groups for each alphabet within each readiness group, for two reasons. Firstly, matching of groups on other salient variables (vision, emotional factors, etc.) would have been risky, since little is known about the importance of these factors in the ability to "read" texture. Neale and Liebert (1973, p. 71) note that the repeated measures procedure, though not without its pitfalls, eliminates variability due to differences in average responsiveness per subject by letting each S serve as his or her own control. The second reason is simply that the number of subjects available for the "low" group was limited.

Subjects

Kindergarten children were divided into high and low reading-readiness groups on the basis of their total scores on the Lee-Clark Reading Readiness Test (1962 edition). This test was administered in separate group settings to

Table 6

Experimental Design, Mapping Sample Means onto Cells

	Alphabet					
	A_1 (standard)		A_2 (textured)		A_3 (backgrounds)	
Group	Latency	errors	latency	errors	latency	errors
Low, n = 14	$\bar{X}_7$	$\bar{X}_{13}$	$\bar{X}_8$	$\bar{X}_{14}$	$\bar{X}_9$	$\bar{X}_{15}$
High, n = 14	$\bar{X}_{10}$	$\bar{X}_{16}$	$\bar{X}_{11}$	$\bar{X}_{17}$	$\bar{X}_{12}$	$\bar{X}_{18}$
Totals	$\bar{X}_1$	$\bar{X}_4$	$\bar{X}_2$	$\bar{X}_5$	$\bar{X}_3$	$\bar{X}_6$

each of seven classes involved in the study. Administration took place from three to six weeks prior to individual testing. Of the 114 children who took the Lee-Clark, only fifteen scored in the "low average" to "low" range, i.e., less than 40 of 64 items correct. Of these 15, seven were in the "low" range (0-32), and eight in the "low average" range. The present low readiness group of subjects, however, contains only 6% of the total 114 pupils in the "low" range, and only 7% in the "low average" range. While the reason for this discrepancy is not clear, it may well represent either a positive shift in kindergarten students' overall readiness level since 1962 (such a shift was observed between 1951 and 1962 norming periods), sampling error due to a small population, or irregularities in test administration which might have boosted scores artificially. No such irregularities are apparent, however, as all test administration instructions were followed precisely. In any case, the experimental groups were taken as the top 15 and bottom 15 scores from the entire group of 114.

Natural attrition occurred in the form of children being withdrawn from kindergarten. This reduced the n's to 14 in each group by the time the experiment was concluded. Of these 28 pupils, the 14 "highs" had a mean Lee-Clark score of 62.14 and a range of 61-63; the 14 "lows" scored a mean of 33.71, with a range of 29-39. Ages at Lee-Clark administration in the high group ranged from 63 to 76 months,

with a mean of 70 months; the range in the low group was from 63 to 79 months, with a mean of 70 months. The mean ages of the two groups did not differ significantly ($t = .082$; $p > .20$). These 28 pupils represent all seven of the classes tapped; five different teachers from the four different schools are represented as well. A confounding of school and class membership with group membership was unavoidable; two schools, representing three classes, provided no pupils in the high group, while the other two schools, representing four classes, provided only three of the low group pupils. The schools and their districts were located in a large Canadian city. A wide spectrum of socioeconomic statuses was included. Two of the schools were from the public, and two from the separate (Roman Catholic) school systems.

Materials

The Lee-Clark Reading Readiness Test (1962 edition) was administered to each class, as noted. Reviewers (Buros, 1968; Robeck & Wilson, 1974) have found the Lee-Clark a reliable instrument (.92 split-half reliability, corrected by the Spearman-Brown formula), as well as a valid predictor of reading achievement by the end of first grade.

There are four subtests to the Lee-Clark: recognition of letter likenesses, discrimination of letter differences, comprehension of verbal instructions, and discrimination of written word similarities. All but the third-named deal

directly with letter-form stimuli, either in isolation or in word form. The test was ultimately administered by the experimenter (E), with the assistance of classroom teachers and their aides, to each class as a group. The first three subtests are timed; on the last and most difficult, pupils work until they have completed all the items they can, as per test administration instructions.

Stimuli were mounted on light grey pebbleboard (Bainbridge #116). At a distance of 838 mm (about 33 inches), the maximum visual angle subtended by a single stimulus was 3.28° vertical by 2.60° horizontal. Horizontal size was much more variable than vertical; background and letter stimuli ranged from 0.68° horizontal for the upper-case "I" to the maximum, stated above, for upper-case "W". Lower-case stimuli, used only in the third session, subtended 3.28° vertical and 1.91° horizontal, with very little variation. Note that the horizontal subtends a smaller angle for the lower-case than the upper, but that the vertical is the same.

For the last eight trials of the third session the horizontal angle was doubled, as four stimuli were presented on a card rather than the usual two. On the first 58 trials, stimuli were placed adjacent to one another with no gap between them; a gap of 5 mm separated the two pairs of stimuli presented in each of the last eight trials however. Upper-case stimuli, used for the first two sessions, were

selected and paired randomly, while lower-case stimuli were paired as highly similar, on the basis of Dunn-Rankin's (1978) similarity matrix. Specifically, lower-case b, c, d, e, and p were used in the last session. One-half of trials (1-58) were "same," with the order of "sames" and "differents" randomized over all three sessions. The last eight trials (59-66) were randomized independently as to order. See Table 7 for a listing of stimuli used.

Stimuli were exposed in the 180° channel of a Gerbrands model T1C 3C three-channel tachistoscope (T-scope). A fixation cross subtending 1.71° both vertically and horizontally was exposed in a 90° channel before each trial. A wooden box with two mounted buttons labeled "same" (left button) or "different" was situated directly in front of the S, and beneath the T-scope viewer. Depression of either button stopped a digital clock (Southwest Technical Products, .01% accuracy) triggered to begin at stimulus exposure, yielding a response latency measure accurate to the nearest millisecond. One of two light-emitting diodes mounted externally on the timer was illuminated each time a button was pushed, so that E could record errors. A disabling mechanism made it impossible for both "same" and "different" responses to be registered simultaneously.

All letter stimuli were Letraset, Helvetica Medium type. Alphabet A_1, the standard alphabet, consisted of letters on white backgrounds; A_2, the textured alphabet, consisted of letters printed on visually textured backgrounds.

Table 7

Stimulus Sequence

Trial no.	Stimuli	Trial no.	Stimuli	Trial no.	Stimuli
1	G_3-Z_3	15	K_2-K_2	29	V_2-V_2
2	L_2-O_2	16	R_3-R_3	30	N_3-S_3
3	K_3-K_3	17	Y_1-Y_1	31	S_2-N_2
4	N_1-J_1	18	A_1-A_1	32	F_3-Y_3
5	H_1-H_1	19	U_3-U_3	33	Y_2-J_2
6	H_3-H_3	20	A_2-A_2	34	S_1-M_1
7	W_1-L_1	21	Q_2-W_2	35	V_1-W_1
8	I_2-I_2	22	X_1-X_1	36	O_3-X_3
9	T_2-M_2	23	T_1-G_1	37	V_3-V_3
10	I_3-W_3	24	U_2-H_2	38	Q_3-T_3
11	G_2-G_2	25	M_3-M_3	39	L_3-A_3
12	F_1-F_1	26	U_1-O_1	40	K_1-Z_1
13	Q_1-Q_1	27	X_2-R_2	41	J_3-J_3
14	Z_2-Z_2	28	R_1-I_1	42	F_2-F_2

Extra Session

Trial no.	Stimuli	Trial no.	Stimuli
43	c_2-e_2	55	p_2-b_2
44	p_2-p_2	56	c_1-c_1
45	b_2-d_2	57	e_2-e_2
46	c_1-e_1	58	p_1-d_1
47	p_2-d_2	59	c_1e_1-e_1c_1
48	p_1-p_1	60	p_2d_2-p_2b_2
49	b_1-d_1	61	b_1p_1-b_1d_1
50	d_2-d_1	62	p_2b_2-p_2b_2
51	b_2-b_2	63	b_1d_1-b_1d_1
52	d_1-b_2	64	c_2e_2-c_2e_2
53	b_1-b_1	65	p_1d_1-p_1d_1
54	p_1-b_1	66	p_2d_2 d_2p_2

$_1$ = A_1 = standard alphabet

$_2$ = A_2 = textured alphabet, complex (TAC)

$_3$ = A_3 = textures alone

Alphabet A_3 consisted of visually textured backgrounds, the same ones used in the A_2 alphabet, but without letters. The 26 visual textures used in the experiment had been selected earlier from 504 such backgrounds on the basis of maximum interstimulus discriminability; see Appendix A for the details of generation and selection of these backgrounds.

Procedure

Individual experimentation took place in an isolated, quiet room (usually the nurse's room) in the school. Subjects were taken from their class by the experimenter, and introduced to the equipment by E's saying "here are all my machines." At the beginning of the first session, S's visual acuity with the preferred eye was measured, using a rotary E chart. When S expressed any doubt regarding eye preference, E tried to determine by further questions or by simple writing tasks whether S was left or right-handed. The result was generalized to represent eye preference as well. E remained blind to the group membership of all Ss until experimentation at the given school was completed.

Following the eye test, S was shown to a seat, and E explained the task as follows: "I'm going to show you some cards. Each card will have two things on it--either two letters, or two bunches of squiggly lines, or two letters on squiggly lines. What I'd like you to do is to tell me if the two things that you see on the card look the same, or different." E than checked S's verbal understanding of the

task by asking "do you understand what I mean?" If S expressed any doubt (none did) or hesitated in answering (a few did), E gave some examples of objects in the room, asking if they looked "same" or "different." Those who initially hesitated clearly had the "same-different" concept.

E then showed three cards to S outside of the T-scope, and S responded verbally either "same" or "different." After the second card, E said "now, I'd like you to answer as fast as you can, but still be sure that you make the right answer." After the third card, E said "now we'll do the same thing, only I'll show you the cards by putting them in this big box (E touched box), and you can see them by looking in here (touched viewer). Now, instead of telling me out loud whether the two things look 'same' or 'different,' I want you to tell me by pressing one of these buttons." E took S's left hand, placed it on the "same" button, and said "now you should press this button when the two things look the same, and this button (took S's right hand and placed it on the "different" button) when the two things look different. OK?" S responded, always in the affirmative.

E next moved around to his chair, loaded the cards, and said "OK (S's name). Now, the first thing you see each time will be this." E exposed fixation cross, directing S's attention to the viewer if necessary. "What would you call that?" Ss' answers were either "a cross" or "an X." E

responded

> Yes--I like to call it a cross. Now, each time I will show you the cross; you look at it and I will ask if you're ready. To be ready, you have to be looking right at the center of the cross. When you say you're ready, then I'll show you the two letters, or the two bunches of squiggly lines, or the two letters on squiggly lines, and you press a button to tell me if they look the same or different. And remember, I want you to push the button as fast as you can, but still make sure that you're right. Now for some practice ones.

The threshold-determining procedure ensued. Sixteen practice stimuli were used; all were upper-case forms of the lower-case stimuli to be used in the third session. Hence, they were stimuli which did not appear in the actual experiment. For the first 14 Ss tested (six in the high group, eight in the low), only the first eight practice stimuli were used. Thresholds were determined in a manner patterned after Kling and Riggs (1971, pp. 14-15): starting at 1000 msec exposure time, successive trials were shortened by 100 msec steps until two consecutive errors were made. Exposure times were then increased by 100 msec steps until two successive correct responses were made. Threshold for exposure time was calculated as the average of the lower of the times for the two successive errors and the higher of the times for the two successive correct responses. For the first 14 Ss errorless performance down to 500 msec resulted in a threshold of 500 msec. Because a number of errorless performances occurred in the practice session with the first 14 pupils, the last 14 Ss' exposure times were

pushed downwards without an arbitrary cutoff point. Table 8 gives the threholds obtained with each subject. It is not clear why eight of the first 14 children obtained thresholds higher than 500 msec, while none of the last 14 thresholds was higher than 300 msec, particularly since three of those eight were high readiness Ss. It is apparent that the experimenter changed the criteria of the threshold-finding procedure between the first 14 Ss' sessions and those of the last 14 Ss. However, threshold differences among subjects were found not to significantly affect the error or latency data (see below). It should also be noted that longer exposure times, by making the discrimination easier, would mitigate against differences among the alphabets in the error data, due to floor effects.

Onionskin paper filters were also placed over the A_2 and A_3 stimuli for the last 14 Ss tested, so that factors of exposure-time differences and filter presence were confounded. The filters were cut, in the case of the A_2 stimuli, so that the letter shape was not filtered; only the background was toned down. However, the differences between filters and nonfilters within each alphabet and each group for both latency and error data were significant at the .05 level in only one of 12 cases (see Table 9), and at the .10 level in only two more cases. Since the .05 case involved the error data for the backgrounds alone (A_3) only for the low group, it is of no experimental importance. The slight

Table 8

Exposure Time Thresholds by Subject

S	Group	Dates of Experimentation	Threshold (Trials 1-58)
G.S.	H	5/11 & 5/17	700 msec
D.W.	H	5/11 & 5/18	900
K.Y.	H	5/12 & 5/18	600
J.M.	H	5/12 & 5/18	500
S.B.	H	5/12 & 5/19	500
T.K.	H	5/15 & 5/19	500
S.J.	L	5/11 & 5/17	1000
N.G.	L	5/15 & 5/19	1000
D.K.	L	5/23 & 5/26	650
J.D.	L	5/23 & 5/26	500
R.P.	L	5/23 & 5/26	500
B.S.	L	5/23 & 5/26	500
D.B.	L	5/19 & 5/29	800
K.H.	L	5/23 & 5/26	700
D.L.	L	5/31 & 6/6	300
J.H.	H	5/30 & 6/6	200
J.G.	H	5/30 & 6/6	200
C.S.	H	5/31 & 6/6	160
L.B.	H	5/31 & 6/6	210
A.M.	H	5/30 & 6/6	200
D.M.	H	5/30 & 6/6	200
T.F.	H	5/30 & 6/7	170
N.P.	H	5/30 & 6/6	160
D.S.	L	6/14 & 6/19	220
T.G.	L	6/9 & 6/15	170
S.N.	L	6/9 & 6/19	230
C.T.	L	6/9 & 6/20	230
F.C.	L	6/15 & 6/20	250

Note. An arbitrary cutoff point of 500 msec was employed for the first 14 Ss, but not for the last 14. Stimulus exposure began at 1000 msec, decreasing in 100 msec steps until two successive errors occurred. Times were then increased by 100 msec steps until two successive correct responses occurred; threshold was taken as the average of the lower of the successive "incorrect" times with the higher of the successive "correct" times.

Table 9

Summary -- First 14 Ss vs. Last 14 Ss, Including Factors of No Filters vs. Filters and Higher vs. Lower Exposure Times

Data	Comparison	Group	t	DF	P	Better Mean
Latencies	NF vs. F, A_1	High	-.218	12	.20 < p	
	NF vs. F, A_2	High	.014	12	.20 < p	
	NF vs. F, A_3	High	.693	12	.20 < p	
	NF vs. F, A_1	Low	-.674	12	.20 < p	
	NF vs. F, A_2	Low	-.853	12	.20 < p	
	NF vs. F, A_3	Low	-.611	12	.20 < p	
Errors	NF vs. F, A_1	High	1.589	12	.10<p<.20	
	NF vs. F, A_2	High	1.988	12	.05<p<.10	(NF)
	NF vs. F, A_3	High	.053	12	.20<p	
	NF vs. F, A_1	Low	1.854	12	.05<p<.10	(NF)
	NF vs. F, A_2	Low	1.410	12	.10<p<.20	
	NF vs. F, A_3	Low	5.075	12	p<.001	NF

( ) denote a trend; other listings in last column denote significance at at least .05 level.

NF denotes no filter; F denotes filter.

"Group" refers to reading readiness group; higher exposure times are confounded with no filters, and lower exposure times with filters.

A_1 denotes standard alphabet.

A_2 denotes textured alphabet (TAC).

A_3 denotes A_2 textures without letters.

indication of an advantage for the no-filter group (first 14 Ss) in the error data is undoubtedly due to the longer exposure times for those Ss. The question of filters and threshold differences will not be considered again here; thresholds in the range employed apparently were not critical to performance in this context, and filters were apparently even less salient than thresholds.

After the first few practice trials, given only on the first session, E said "Oh--if you should press the wrong button by mistake, be sure to let me know, so I can write down the answer you really mean." Once threshold was established, at the completion of practice trials, each S was given the opportunity to rest. Few did. During each session a very regular rhythm was gradually established: "There's the cross. Ready?" "Yes."

E then exposed the stimuli, response was made, time and R recorded, stimuli advanced, and timer and response-indicator light reset. E gave verbal feedback after each response, usually "good" or "OK," with the S's name at the end of the phrase. If an error was made, E would say "no, that was (same or different). But that's OK. Don't worry about it." The last two phrases were used only with Ss who showed considerable anxiety about their performance; this was about half of the total group.

Stimuli were randomized over the first two sessions, 21 trials in each, which occurred on two separate days, and

included 14 stimuli from each of the three alphabets. The last session, on a third day, included only stimuli from the standard and textured alphabets (A_1 & A_2). The first and third days were never more than seven days apart; absences, weekends, field trips and school holidays kept the spacing of sessions irregular over Ss. See Table 7 for a list of the stimuli used in each session. Before the last eight trials (doubled stimuli), each S was told that the rules were going to change now, and that he/she would have to decide if the first two stimuli looked the same or different from the second two. Eight practice trials were given, using stimuli which were not to occur in the last eight trials; and, for the last 14 Ss, the exposure time threshold was taken again, starting 50 msec longer than the established threshold and increasing by 50 msec steps if errors were made. It was assumed, for these Ss, that their lower initial thresholds would make the task with four stimuli too difficult. However, as noted, threshold changes did not significantly affect the data between subjects.

Each of the three sessions lasted 20 to 30 minutes per subject; variations were due to rest breaks, S's speed, and occasional interruptions by people needing the nurse's room, or by school announcements.

Results

Four different sets of data were analyzed: latencies and errors for trials 1-58, and latencies and errors for

trials 59-66. Data for trials 1-58 were mean latencies and errors per trial per subject; sums could not be used because each subject had fewer trials (14) for the A_3 alphabet (textures alone) than for the A_1 (standard Roman alphabet) and A_2 (TAC), both of which were presented in 22 trials to each S. Data for trials 59-66 were totals per subject; only the A_1 and A_2 alphabets were involved in the last set of analyses.

The ANOVA for latencies, trials 1-58, took the form of a 3 X 2 (alphabets by groups) with repeated measures on the alphabets factor. The main effect due to groups was not significant at the .05 level, but approached it ($p < .10$). The alphabets effect was highly significant ($p < .005$). Their interaction was negligible (see Table 10 & Figure 2). Newman-Keuls analyses revealed that the alphabets effect found in the ANOVA was due solely to the longer latencies obtained with the A_3 alphabet. Thus prediction 1b was supported, indicating, as one might expect, that response latencies are significantly shorter to textured alphabet (TAC) stimuli than to stimuli composed only of the textured backgrounds. The standard alphabet latencies were also shorter than those for the textures alone. The differences between mean latencies for A_1 and A_2 were not significant, however, for either group, thus failing to lend support to prediction 1a. Aside from the hypotheses, Figure 2 and Table 9 clearly indicate that the Lee-Clark Reading

Table 10

Data Summary -- Latencies, Trials 1-58

ANOVA

Source	SS	DF	MS	F	P
Between Subjects	31.1348				
Groups	4.0248	1	4.0248	3.86	.05<p<.10
Ss within Groups	27.11	26	1.0427		
Within Subjects	5.0844				
Alphabets	2.4466	2	1.2233	24.417	<.005
Groups X Alphabets	.0302	2	.0151	NSF	
Subjects X Alphabets interaction, summed over groups	2.6076	52	.0501		

Newman-Keuls, High Group Means

	A_1, High 1.4210	A_2, High 1.5312	A_3, High 1.8071
A_1, High 1.4210	--	.1102	.3861*
A_2, High 1.5312		--	.2759*
A_3, High 1.8071			--

Newman-Keuls, Low Group Means

	A_1, Low 1.8780	A_2, Low 1.9160	A_3, Low 2.2786
A_1, Low 1.8780	--	.038	.4006*
A_2, Low 1.9160		--	.3626*
A_3, Low 2.2786			--

*denotes significance at the .05 level.

A_1 denotes standard alphabet. A_2 denotes textured alphabet (TAC). A_3 denotes A_2 textures without letters.

Note. The alphabets effect revealed in the ANOVA is entirely due to the inferiority of the A_3 stimuli to both of the other alphabets.

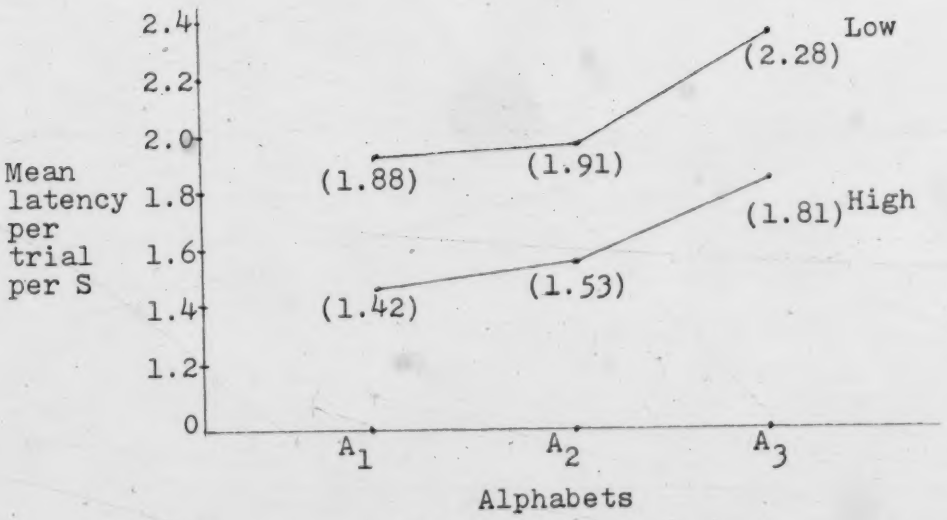

Figure 2. Mean Latencies Per Trial Per Subject, Trials 1-58

A_1 denotes standard alphabet. A_2 denotes textured alphabet (TAC). A_3 denotes A_2 textures without letters.

The groups effect is significant at the .10, but not at the .05 level (see Table 10). There is no interaction of groups with alphabets.

Readiness Test successfully differentiated the groups on their ability to discriminate letter forms.

The ANOVA for errors, trials 1-58, revealed the main effects due to both groups and alphabets to be highly significant ($p < .005$ in both cases); their interaction just missed significance at the .05 level (see Table 11). Newman-Keuls multiple comparisons, however, revealed that both main effects could be attributed solely to the high error rate of the low group with the A_3 alphabet (textures alone). Overall error rates were quite low for trials 1-58: the high group's rate was only 1.5%, while the lows erred at a rate of 7.6%. The prediction of the superiority for the textured alphabet (TAC) to the standard alphabet (prediction 1c) was therefore not supported by analysis of errors in trials 1-58. Prediction 1d, superiority of the TAC to the textures alone, was supported, but is of little interest. Again, however, groups are clearly differentiated by the Lee-Clark. Appendix D gives standard deviations for all data.

The ANOVA for trials 59-66, which involved doubled, lower-case stimuli, took the form of a 2 X 2 (alphabets by groups), with repeated measures on the alphabets factor. No significant main effects or interactions for errors or latencies were revealed (see Table 12). Newman-Keuls and t-tests, run strictly as checks (not shown), supported the finding that no significant differences existed for these last eight trials. This represents a further failure to

Table 11

Data Summary -- Errors, Trials 1-58

ANOVA

Source	SS	DF	MS	F	P
Between Subjects	.67814				
Groups	.28765	1	.28765	19.151	<.005
Ss within Groups	.39049	26	.01502		
Within Subjects	.70889				
Alphabets	.17987	2	.08994	9.894	<.005
Groups X Alphabets	.05639	2	.02820	3.102	.05<p<.10
Subjects X Alphabets, summed over groups	.47263	52	.00909		

Newman-Keuls, High Group Means

	A_1, High .0130	A_2, High .0260	A_3, High .0612
A_1, High .0130	--	.013	.0482
A_2, High .0260		--	.0352
A_3, High .0612			--

Newman-Keuls, Low Group Means

	A_1, Low .0812	A_2, Low .1201	A_3, Low .250
A_1, Low .0812	--	.0389	.1688*
A_2, Low .1201		--	.1299*
A_3, Low .250			--

* denotes significance at the .05 level.

A_1 denotes standard alphabet. A_2 denotes textured alphabet (TAC). A_3 denotes A_2 textures without letters.

Note. Both main effects in the ANOVA, as well as the near significance of their interaction, may be attributed to the relatively high error rate of the low group with the A_3 stimuli.

Table 12

ANOVA Summaries, Trials 59-66

Latencies

Source	SS	DF	MS	F	P
Between Subjects	644.837				
Groups	.728	1	.728	NSF	
Subjects within Groups	644.109	26	24.773		
Within Subjects	50.007				
Alphabets	.676	1	.676	NSF	
Groups X Alphabets	1.614	1	1.614	NSF	
Subjects X Alphabets, summed over Groups	47.717	26	1.835		

Errors

Source	SS	DF	MS	F	P
Between Subjects	15.857				
Groups	1.143	1	1.143	2.019	$.10<p<.25$
Subjects within Groups	14.714	26	.566		
Within Subjects	23.000				
Alphabets	.071	1	.071	NSF	
Groups X Alphabets	1.786	1	1.786	2.197	$.10<p<.25$
Subjects X Alphabets, summed over Groups	21.143	26	.813		

Note. No main effects nor interactions reach significance for data from trials 59-66. These trials involved a change of task; Ss were required to judged whether two pairs of confusable, lower-case stimuli were "same" or "different."

support predictions 1a and 1c. As no A_3 stimuli were involved in the last eight trials, nor, indeed, in the last experimental session, these findings have no bearing on predictions 1b and 1d.

Predictions derived from hypothesis 2 were evaluated in a different manner, and thus warrant separate reporting. Though the interactions from the ANOVAs performed to test hypothesis set 1 were not significant, a more direct test of the hypothesis set 2 was still needed, in view of the near significance of one such interaction (Table 11). In order to test the significance of differences between mean differences between correlated means, a t statistic of the form $t = \frac{\bar{D}_1 - \bar{D}_2}{S_{\bar{D}_1 - \bar{D}_2}}$ was calculated for each of the four subhypotheses of hypothesis 2. The standard error of each such difference was calculated as $S_{\bar{D}_1 - \bar{D}_2} = \frac{\Sigma(D_1 - \bar{D}_1)^2 + \Sigma(D_2 - \bar{D}_2)^2}{N(N-1)}$, where N = 14, the number of subjects in each group. The results of these tests are reported in Table 13: of four such tests, only one reached the .05 level of significance. It was prediction 2b which received support, indicating that the advantage of the A_2s over the A_3s (TAC over the textures alone) was significantly greater for the low than for the high readiness group when mean latencies were the data base.

A posteriori analyses were performed to examine the

Table 13

Hypothesis 2 Tests

Data	Comparison	Prediction & Hypothesis	t	DF	P
Latencies	(A_2-A_1) Low vs. (A_2-A_1) High	2a	1.243	13	$> .20$
	(A_2-A_3) Low* vs. (A_2-A_3) High	2b	3.94	13	$.001 < p < .01$
Errors	(A_2-A_1) Low vs. (A_2-A_1) High	2c	1.21	13	$> .20$
	(A_2-A_3) Low vs. (A_2-A_3)	2d	1.55	13	$.10 < p < .20$

*denotes significantly better mean.

A_1 denotes standard alphabet.

A_2 denotes textured alphabet (TAC).

A_3 denotes A_2 textures without letters.

Note. These tests represent comparisons of the differences between the TAC and each of the other two alphabets between the two groups, as hypothesis 2 predicts a greater advantage of the TAC for the low group than the high. Only one such difference, the advantage of the TAC over the A_3 (textures alone), revealed a significantly greater advantage for the low group.

effects of upper-case vs. lower-case letters, and to test the differences between "same" and "different" correct responses. Table 14 gives the results of the six t-tests performed for the upper-case vs. lower-case analysis; only the difference for the low group, TAC, error data was significant, in favor of the upper-case stimuli. As these results represent a confounding of session differences (1st & 2nd vs. 3rd) with upper-case vs. lower-case differences, interpretation of the single significant, and one nearly significant result must be quite guarded. It is possible that the indication of an advantage for the upper-case letters with the low group could reflect some differential of familiarity with lower-case letters between the groups. Low group pupils may have had less exposure to lower-case letters, and might therefore tend to make more matching errors with them. Errors for the high group were not tested, as the overall error rate for the group through trials 1-58 was only 1.5%, as compared to 7.6% for the low group, as noted above.

Table 15 gives the results of the nine t-tests performed for correct "same" vs. "different" responses. The overall test showed the "sames" to be faster than the "differents" at a high level of significance ($p < .001$); this general result was repeated for sames vs. differents in A_1 overall, A_2 overall, highs overall, lows overall, and in three of four subtests, though significances varied. Only the t-test for

Table 14

Summary -- Upper-case vs. Lower-case Stimuli

Data	Comparison	t	DF	P	Better Mean
Latencies	High (A_1)	.039	13	>.20	
	High (A_2)	.575	13	>.20	
	Low (A_1)	1.137	13	>.20	
	Low (A_2)	.973	13	>.20	
Errors	Low (A_1)	1.807	13	.05<p<.10	(u.c.)
	Low (A_2)	3.635	13	.001<p<.01	u.c.

( ) denote a trend; other listings in last column denote significance at at least .05 level.

A_1 denotes standard alphabet.

A_2 denotes textured alphabet (TAC).

A_3 denotes A_2 textures without letters.

Note. Though factors of letter case and sessions are confounded, there is still some indication that the low group may have made fewer errors with upper-case than with lower-case stimuli.

Table 15

Summary -- Correct Same vs. Different Responses

Data	Comparison	t	DF	P	Better Mean?
Latencies	Overall	4.102	27	$<.001$	same
	A_1 (overall)	2.205	27	$.02<p<.05$	same
	High (A_1)	2.332	13	$.02<p<.05$	same
	Low (A_1)	.762	13	$>.20$	
	A_2 (overall)	4.293	27	$<.001$	same
	High (A_2)	3.985	13	$.001<p<.01$	same
	Low (A_2)	2.519	13	$.02<p<.05$	same
	High (overall)	4.409	13	$<.001$	same
	Low (overall)	2.236	13	$.02<p<.05$	same

Listings in last column denote significance at at least .05 level.

A_1 denotes standard alphabet.

A_2 denotes textured alphabet (TAC).

A_3 denotes A_2 textures without letters.

Note. Only correct trials were included in these tests. There is a strong indication that "same" responses were faster than "different" responses throughout the experiment.

the same-different comparison with the standard alphabet, low group, failed to reach the .05 level. While a certain risk of finding a significant result by chance arises when such a long series of t-tests is performed, the generality of the result that "same" responses were significantly faster than "different" responses throughout the experiment cannot be seriously questioned.

Letter-by-letter analyses of both sets of data from trials 1-58 were also performed, in order to give some indication as to which A_2 stimuli were most effective, and which might require some alteration. Appendix E gives the results of these analyses.

Discussion

The lack of support for any part of hypothesis set 1 save the superiority of both the standard and textured alphabets to the A_3 alphabet, composed only of backgrounds, raises questions in light of the results Clement reported. While the present textured alphabet (TAC) did not enhance letter discriminability over the standard Roman, the problem is of sufficient interest to have led to subsequent research of a pilot nature being conducted. The outcome of this research is reported in Appendices B and C. These two studies reveal differences between alphabets not found in the main study.

Appendix B reports effects obtained by presenting stimuli successively rather than simultaneously. The subject population of this pilot study was "learning disabled" children, aged six to nine years. The results show differences between the TAS and TAC alphabets. Appendix C reports results when cerebral palsied

children aged five to 14 years were presented the various alphabetic materials in a successive mode. Difficulties were experienced in the form of high response variability which make it hazardous to generalize the results. However, the data are of interest because they are consistent with the results reported in Appendix B.

Returning to the main study, lack of support for hypothesis set 2, save for one instance of a greater advantage of the textured alphabet over the A_3 alphabet for the low group than for the high, raises a number of interrelated issues in addition to those mentioned for hypothesis set 1. In particular, the perceptual deficit hypothesis of reading dysfunction deserves closer attention, since hypothesis set 2 draw much of its rationale from the notions (a) that many children with reading problems have visual-perceptual difficulties, and (b) that the low readiness group had much in common with the reading difficulties groups which are the focus of the perceptual deficit literature. That reading problems and perceptual problems go together is supported by the literature cited in the "hypotheses and predictions" section of this paper, as well as by Rouch (1967), who found significant relationships between first-graders' scores on the figure-ground subtest from the Frostig Developmental Test of Visual Perception and their reading achievement scores.

However, Buckland (1969) found no advantage of training

low-readiness first-graders with the Frostig Program for the Development of Visual Perception over normal classroom procedures, when Ss were evaluated with the Frostig test for that program, the B form of the Metropolitan Readiness Test, and the word recognition section of the primary New Developmental Reading Test, in a pretest-posttest design. While he concludes that "it appears to be the language experience and not the visual perception training which benefits elementary age children" (p. 93), his results are clouded by the fact that only 40 days elapsed between his pretests, whereas the Frostig program is designed to improve visual perceptual and reading skills over more extended time periods.

Goins (1958), using a tachistoscope to improve visual discrimination skills of first-graders simply by increasing speed and efficiency of processing, found that, while performance in the task did improve significantly for good readers, poor readers showed little effect, and neither group showed reading skill progress "concurrent with gains in tachistiscopic skill" (p. 101). Stimuli used in the T-scope were pictures of objects and geometric forms. Goins implied that her results do not support the existence of a "p-factor," proposed by Thurstone as a general ability to perceive detail when it is embedded in irrelevant material, and which he thought might be an underlying factor in reading disabilities, if poorly developed.

A sizeable body of recent work, primarily by Stanley and his colleagues, has probed the possibility that reading disabilities might stem from abnormalities in the iconic or short-term stages of visual memory. Hochberg (1968) has outlined the general point-of-view:

> does learning affect the way we see the words - that is, the way we pick up their forms initially - or does learning to read only alter the ways in which these forms are stored and remembered? (p. 325)

His answer:

> the effects of perceptual learning consist of changes in where you look, and of how you remember what you saw, but not of changes in what you see in any momentary glance. (p. 326)

Stanley's basic hypothesis is that dyslexic children process information more slowly during the visual information store (VIS), or iconic phase of visual perception, and that this deficit underlies their reading difficulties by delaying transfer into short-term visual memory (Stanley, 1975; Stanley & Hall, 1973). His basic research paradigm, exemplified by the latter study, presents two-part stimuli, such as two halves of a cross, in an oscilloscope at varying ISIs to normal and dyslexic groups, and measures differences between separation and identification ISIs between the groups--i.e., differences in the ISIs at which S first reports a non-composite figure (separation ISI), and at which S correctly identifies the two parts of the display (identification ISI). The dyslexic groups, ages eight to twelve in the 1973 study, show overall

separation ISIs which are 30 to 50 msec longer than those of normal groups. The identification ISIs of the dyslexics, though not a direct reflection of VIS duration, are typically almost twice as long as those of normals, reflecing a generally slower processing of such stimuli by dyslexics. In studies which directly compare dyslexics and normals from ages eight to twelve (grades two to six) on tasks such as visual and auditory sequential memory, visual matching with spatial transformation, copying letters, and oral reading and spelling, dyslexics perform worse than normals only on memory tasks, pronunciation, and oral spelling. Their abilities to copy figures, letters, and words, and to name letters both within a word and in isolation were no different from those of normal children (Stanley, Kaplan, & Poole, 1975; Vellutino, Smith, Steger, & Kaman, 1975). These authors conclude that the deficits of dyslexics involve memorial and "verbal mediation" skills (which may be the same thing), rather than visual-spatial disorders.

However, Stanley (1975) compared dyslexic and normal children in their speed and accuracy in identifying digits exposed for 20 msec and masked after various intervals, and found dyslexics to be <u>superior</u> in accuracy and slightly, though not significantly faster than their normal classmates. While he suggests that VIS persistence could actually have aided the dyslexics in making the visual

match between the displayed figure and the numbered response button, Arnett and DiLollo (in press) attribute Stanley's (1976) results to response criterion differences between this study and Stanley and Hall (1973). Arnett and DiLollo, using a backward masking paradigm in which normal and poor readers of various ages made a forced-choice as to which side of a briefly-exposed display had contained a missing dot, found no group differences save the expected age differences, and concluded that the "visual persistence" of the poorer readers was no different from that of normals at all four age levels examined.

Results similar to those of Stanley's group--that dyslexics differ from normals primarily in factors of sequencing and visual memory--have been interpreted by Hurley (1972) as a failure to support an "intersensory integration" view of reading problems, that "reading is a skill involving directionality and orientation" (p. 149). While Fisher and Frankfurter (1977) also failed to find perceptual deficits among dyslexics in letter identification and spatial localization tasks, they propose that such children lag developmentally in the ability to integrate verbal material. In addition, they found no evidence for a persistence of iconic storage in dyslexics, as these subjects actually outperformed their younger, normal couterparts, matched for reading level. DiLollo and Arnett have commented that the latter result is at odds with the

rest of the literature, and is "only suggestive," at best.

Clearly, the perceptual deficit vs. visual memory vs. verbal integration views of reading disability cannot be resolved at this time; their predictions are not always distinct, and contradiction abounds in the literature. While the present study has found no evidence of a visual-perceptual deficit in the low-reading-readiness group, at least as measurable in the tachistoscopic paradigm, it should be kept in mind that these children were not necessarily comparable to the "reading disabled" groups of the above studies, in spite of the very poor skills demonstrated by some of the low group children. Diagnostics are a huge problem in this area, as Stanley (1975) has noted:

> It could be argued that the sample referred to as dyslexic is not representative of the syndrome of reading difficulty. Although there is a current trend in educational circles to treat all reading difficulties without regard to diagnostics, it is our belief that there is some value in a careful differentiation of subgroups of children with reading failure. (p. 191)

His caution is doubly warranted when dealing with a sample which has not demonstrated "reading failure," but only poor readiness to learn to read. Though the instrument used to evaluate the present children (the Lee-Clark) has been found to predict reading achievement at the end of first grade with a correlation of .67 (Robeck & Wilson, p. 363), this still gives only a rough indication as to how many Ss in the low group might actually have become

"dyslexic" in later years.

As noted in the results, there were different rates of error with upper-case than with lower-case letters. While these differences were not hypothesized, they do bear upon the processing of letter forms in general, and deserve to be discussed. There were significantly fewer errors with upper-case than with lower-case letters for the low group seeing the textured alphabet (TAC). This is somewhat difficult to interpret, considering the confounding of letter case with experimental sessions. Also, a trend towards superiority of the upper-case letters appeared in the error data for the lows with the standard alphabet. It therefore appears that letter case effects may depend upon the given task. While speed of response showed no effects due to letter case, accuracy of same-different judgments may be increased by the use of upper-case stimuli with children at a low readiness level. As has been noted, these results might simply reflect a greater use of upper-case stimuli with kindergarten children, particularly those in the low group, so that any accuracy advantage may be due to familiarity effects. But it is difficult to understand why response latencies would not show the effect of familiarity as well; Egeth and Blecker (1971) have found response latency decreases with various familiarity increases, particularly for correct "same" responses.

The significant response latency advantage of the

correct "same" responses in the present study over both groups and both textured and standard alphabets agrees with a number of studies on "same" vs. "different" processing (Bamber, 1969; Barron & Pittenger, 1974; Egeth & Blecker, 1971; Kreuger, 1973b; Sekuler & Abrams, 1968). Though these studies represent a wide spectrum of procedures and stimuli being compared, from single letters (Bamber) to CVC trigrams (Egeth & Blecker) to words and pseudo-words (Barron & Pittenger) to patterns (Nickerson; Sekuler & Abrams), all found "same" latencies to be shorter than "different," given certain conditions of discrimination difficulty. The model most often invoked to explain such results is Bamber's, in which an "identity reporter" with only one potential signal ("same") operates more quickly than a "serial processor," which has both "same" and "different" signals in its repertoire. This model is echoed in Sekular and Abrams' distinction between "extraction" and "comparison" processes, and in Posner and Mitchell's (1967) chronometric processing model, with a rapid "physical identity" node, a medium-speed node for "name identity" (e.g., A with a), and a slower node for "rule identity" (e.g., "both vowels," or "both consonants"), with a "different" response occurring only after processing at the third node.

Though this literature, bearing as it does on the nature of serial vs. parallel processing, is too vast to explore here, it would be misleading to omit at least a few

of the refinements and contradictions relating to these multi-process models. Task difficulty is considered a salient variable; Nickerson (1969) predicts that "different" latencies will be shorter than "same" when error rates are low--i.e., with relatively easy tasks--and that high error rates are required to reverse this situation. Though the results of the present study do not agree, given its long exposure times and low error rates, Nickerson's predictions have been supported by several studies (Bindra, Donderi, & Nishisato, 1968; Egeth, 1966; Kreuger, 1973a). Nickerson (1967) found that "different" responses to geometric figures differing on three dimensions (size, color, and shape) were more rapid than "same" responses with these stimuli, which, in turn, were more rapid than "different" responses when only one dimension differed. Kreuger (1970) has found evidence for a tradeoff between speed and accuracy when irrelevant brackets are briefly placed around adjacent letters, with bracket-height affecting "different" latencies, but not "same," and error rates being higher for the more rapid "same" responses. This suggestion that subject expectation or "response value" enters into the data is reinforced by Nickerson (1967), who wondered whether a subjective bias might not exist in favor of the "same" response, since the phrase "same or different" is much more common in the language than is "different or same." In any case, the

marked speed advantage of "same" responses over "different" in the present study does nothing to refute or contradict the multi-process models of such decisions.

Research Implications and Recommendations

Beyond laboratory studies such as those reported in Appendices B and C, a need exists for classroom experimentation with textured alphabet instructional material. A possible model for such experimentation is provided by David Bain (1976), who presented graphically augmented letters and words to children in a classroom testing situation. Pupils were presented with printed materials in which items in a given row were highly similar, but represented varying types and degrees of modification of the letters of the first word in the row. The child's task was to mark the letter in the row which was exactly like the first; errors were the critical data, and gave indications as to which letter modifications were most helpful to the children. A similar approach might help to further clarify the differences between the standard alphabet, textured alphabet, complex (TAC), and textured alphabet, simple (TAS).

A salient issue is the effect of fading procedures on learned letter contours; though the textured alphabet has been designed to facilitate fading by matching curved letters with straight-line backgrounds, and vice-versa (see

Appendix A), the efficacy of such a procedure, as well as optimal rate of fading and other parameters, remain as experimental questions at the present time. Samuels (1967; 1968) argues that, while "distracting background stimuli" such as pictures, and methods of isolating an item in a list such as different colors may improve discrimination performance during training, transfer results when these supporting stimuli are absent show a disadvantage of children trained with such stimuli. Though he attributes these results to the principle of least effect, by which the S "tends to focus upon that dimension of the stimulus which most reliably elicits a response leading to reinforcement" (1968, p. 437), he made no attempt to gradually fade out the supporting stimuli between training and transfer tests. In contrast, Griffiths and Griffiths (1977) report errorless performance on a delayed transfer task when visually augmented, reversible letters were the training stimuli for preschool children, with the supporting stimuli faded completely, but gradually, before the transfer test.

Regarding questions raised in the introduction concerning the relationship between the present textured alphabet and an "ideal" alphabet in terms of the distinctive feature model, the results of the pilot study indicate that the present alphabet may be superior to the "dotted" alphabet, though this interpretation is difficult

to reconcile with Clement's (Note 1) results. It should be noted, however, that Clement's first study method, while unclear in detail, undoubtedly involved exposure of stimuli up to the time S made his or her response. Thus a certainty factor was in operation, much as in actual reading or learning to read, in which S was able to take as much time as he or she needed to process the material before making a response. Clement's apparently low mean latencies (Table 2) are no proof against this interpretation, since details of timing and data treatment are lacking. The present research, by contrast, presents stimuli in a brief chunk of information whose availability is beyond subject control. It thus allies itself more with information processing views of reading than with pedagogical approaches. Methods for textured alphabet research which are not closely linked to information processing theory, such as classroom studies mentioned above, would seem a logical next step.

If further results continue to indicate an advantage of the textured alphabet over the dotted, or even the standard, then no necessary changes in the textured backgrounds are recommended at present. However, if later results confirm either Clement's or those of the present study in failing to show clearcut advantages of the textured alphabet over the standard while the dotted stimuli do produce such an effect, it is recommended that the textured backgrounds be simplified somewhat, while taking care not to interfere

significantly with the mutual discriminability of the backgrounds. Simplification is indicated, rather than increased contour complexity, partly on an intuitive basis, and partly on the basis of informal observations made by several teachers and researchers in learning disabilities that the textured alphabet backgrounds are "noisy" in appearance. This concurs with Piaget's notion of "centration"--that a single item or feature in an array of stimuli will serve as a focal point of attention and interest of the child as observer, and that other aspects of the array will be "assimilated" to it (1962, pp. 235 & 242). It is possible that the TAC backgrounds are centrating the Ss on non-letter features. The optimal degree of simplification, if indicated, is open to testing.

Methodologically, the high within-subjects variability in the present and pilot data can be reduced by shortening exposure times so as to limit the subject to a single eye fixation (e.g., around 40 msec for all subjects), and by instructing subjects to begin each trial with their fingers resting on the response buttons. This procedure was used in a number of the studies on same vs. different processing cited above, which also suggest that providing incentives to Ss for correct responding might further reduce the uncontrolled variance within subjects, thus decreasing the likelihood that any effects of the alphabets, groups, or presentation modes will be hidden by random error.

Steps should also be taken to construct a confusion matrix for the TAC textures alone, in order to further refine the matching of confusable letters with nonconfusable backgrounds. Such a matrix should be obtained, and appropriate changes made in the letter-background pairings of the TAC, prior to the pursuit of further research in either lab or classroom.

In conclusion, it should be noted that the results of this study, in which no evidence was found to support the hypothesis that a textured alphabet can enhance discriminability of letter stimuli over the standard Roman alphabet, should not be taken as salient evidence either for or against the two models proposed above for the operation of a textured alphabet. While the present alphabet's fit to these models has not been supported by this study, results from the pilot work, particularly Appendix B, clearly indicate that different backgrounds can significantly alter letter discriminability, which is an outcome predicted by both the "distinctive feature" and "ideographic-phonetic" models. Further tests of textured alphabets, perhaps modified along lines suggested above, against the present textured alphabets (TAC & TAS) and the standard Roman in both laboratory and classroom experiments are necessary before questions concerning the validity of these models can be even approximately answered.

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Appendix A

Design and Selection of the Textured Alphabet Stimuli (Note 3, Note 4).

Jorge Frascara of the Department of Art and Design, University of Alberta, developed the background textures of the TAC in order to improve their distinctiveness over the "Letratone" dot patterns used in Clement's (1970) work (TAS). Whereas the Letratone patterns could be varied only along dimensions of fineness and darkness, (i.e., dot size and dot density), Frascara's stimuli could be varied on six different dimensions over 19 different variables, as:

1) Shape of component	1) Dot	3) Dash
	2) Line	
2) Percentage of black	4) 6%	6) 24%
	5) 12%	
3) Fineness	7) Thick	8) Thin
4) Shape of pattern	9) Straight	10) Curved
5) Interval	11) Regular	12) Irregular
6) Direction	13) Vertical	
	14) Horizontal	
	15) Vertical & horizontal	
	16) Diagonal, 60°	
	17) two 60° diagonals, crossed	
	18) two 30° diagonals, crossed	

19) two 45° diagonals, crossed

Of 504 potential textures, Frascara and his students actually produced 220 by photographic means from 12 originals done in Letraset and recombined with one another. The 284 stimuli not produced were judged too perceptually similar to the others to be useful as letter backgrounds.

Selection of 30 backgrounds (to allow for use with various alphabets: Arabic, Cyrillic, etc.) was carried out by Dr. Carol Ladan and Dr. T.M. Nelson of the Psychology Department, University of Alberta. There were six separate steps to the psychophysics of selection. Briefly, these were: (1) separation of the 220 stimuli into twelve groups on the basis of curvature, line thickness and blackness dimensions, and ranking of the stimuli in each group by fours as to distinctiveness--four Os were used in this stage; (2) selection of two sets of 30 stimuli each from step (1) stimuli (by two Os) on the basis of intraset distinctiveness; (3) separation and scaling, first of all 220 stimuli, then of the two groups of 30, by 50 undergraduate psychology observers taking the stimuli in groups of five; (4) final selection of 15 stimuli which were (a) selected for a group of 30, (b) chosen as "most distinctive" from the 44 sets of five stimuli each, and (c) judged discriminably different from all other stimuli by student raters; (5) selection of 60 more stimuli on the basis of distinctiveness judgments of the original sets of five (i.e., many "second most

distinctive" stimuli were included here) and including "dummy" stimuli, and (6) scaling of these 60 stimuli by 40 new student observers, essentially repeating steps (3) and (4). A total of 30 stimuli resulted from the six steps.

Pairing of letters with backgrounds was done by J. Frascara and W. Junkind on the basis of minimal contour interference. This match was made in order to facilitate eventual fading out of the textures in later stages of reading development. Griffiths and Griffiths (1976) report errorless performance with a fading procedure involving preschool children and 'augmented' reversible letters. Thus, in the TAC, curved letters were imposed on straight-line backgrounds, and vice-versa.

Photos of the A_2 (TAC) stimuli follow this page. These photos are considerably larger than the stimuli employed in the three experiments reported, and are included primarily to concretize the reader's understanding of the effects which the changes in variables described above have on the actual appearance of the letter-background combinations.

A

B

C

D

E

F

G

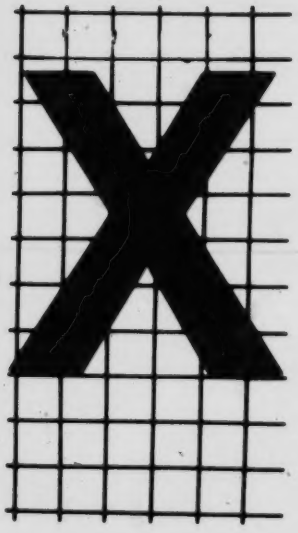
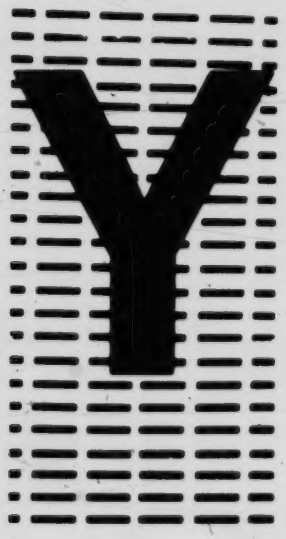
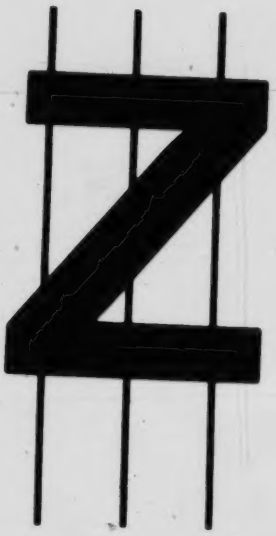
H

I

J K L

M N O

P Q R

Appendix B: First Pilot Study

In the summer of 1978, a pilot study was conducted in order to compare effects of the textured, dotted, and standard alphabets with learning disabled children in a successive mode of presentation of stimuli. Fourteen subjects were run; all were selected on the basis of their attendance at a school for the learning disabled, and ranged in age from 77 to 109 months. There were only two girls in the sample.

As a screening device, the Lee-Clark Reading Readiness Test was administered to all 36 of the children available at the school; only two were eliminated as potential subjects on the basis of their extreme difficulty with the test. The 14 subjects' scores ranged from 38 to 63 (of 64), with only one score below 50. Scores generally improved with subject's age; the 38 was scored by the youngest subject. However, another subject only one month older scored 58 on the Lee-Clark; she was to attend the public school in the fall. The usefulness of the test as a diagnostic device for reading problems is obviously confined to the age range for which it was designed (K to early first grade).

Materials were identical to those in the research reported in the body of this paper, with the exception that pairs, trios, and quads of letters were used as stimuli in a successive presentation mode. Thus, visual angle

subtended by a single stimulus ranged from 3.28° vertical by 3.82° horizontal for a lower-case pair to 3.28° vertical by 10.4° horizontal for an upper-case quad. Lower-case stimuli were selected from Dunn-Rankin's (1978) matrix as highly similar; upper-case were drawn from Gibson, Osser, Schiff, and Smith's (1963) confusion matrices. An equal number of lower-case and upper-case trials was presented; see Tables A and B for a list of stimuli. Of the 102 trials planned, 11 Ss completed only 77, one completed only 58, and two completed all 102, due to time constraints. Randomization of letter-case, alphabets, and same-different trials across all 102 trials thus led to slightly higher numbers of "same" and upper-case trials for the 12 Ss who did not complete all 102 trials. The eleven Ss with 77 trials saw 27 standard, 25 textured, and 25 dotted trials; the two Ss with 102 trials saw 34 trials of each alphabet, and the S with only 58 trials saw 22 standard, 16 textured, and 20 dotted trials. There were 35 pairs, 30 trios, and 12 quads, in that order, for the eleven Ss who had 77 trials; 60 pairs, 30 trios, and 12 quads for the two who had 102 trials, and 31 pairs, 15 trios, and 12 quads for the one S who had only 58 trials. The same 25 trials, numbers 26-50 (inclusive), were omitted for the eleven; the single S missed these 25 trials, as well as 57-75 (inclusive).

Procedures were also identical to those for the previous study, except that visual acuity was not taken,

Table A

First Pilot Study Stimuli

Trail	Stimuli	Trial	Stimuli	Trial	Stimuli
1	MW_1-WW_1	26	QO_4-QQ_4	51	mw_1-mm_1
2	QQ_2-QQ_2	27	ec_1-cc_1	52	bd_2-bd_2
3	EF_1-EF_1	28	ec_2-ce_2	53	bb_4-bb_4
4	OO_2-QQ_2	29	wm_4-wm_4	54	db_1-bd_1
5	MM_2-MM_2	30	QO_1-QO_1	55	RP_4-PP_4
6	NM_2-NN_2	31	ec_4-ec_4	56	bb_1-bb_1
7	MW_1-MW_1	32	ec_4-ee_4	57	mw_2-mw_2
8	OQ_4-OQ_4	33	EE_2-EE_2	58	mm_1-mm_1
9	FE_4-FE_4	34	NN_4-NN_4	59	pb_1-pb_1
10	RP_2-RP_2	35	wn_2-ww_2	60	cc_1-cc_1
11	MW_4-WM_4	36	bp_2-bp_2	61	XYK_2-XYK_2
12	PP_2-RR_2	37	pb_1-pp_1	62	eoc_4-eco_4
13	PR_1-PP_1	38	MN_1-MN_1	63	NWM_2-NWM_2
14	EE_4-FF_4	39	MM_1-NN_1	64	lfi_4-lfi_4
15	un_2-nn_2	40	MM_4-MM_4	65	MWN_4-MWN_4
16	PP_4-PP_4	41	db_2-dd_2	66	eco_1-oec_1
17	MN_4-NM_4	42	ce_2-cc_2	67	unm_2-unm_2
18	un_2-un_2	43	pp_2-bb_2	68	KXY_1-XKY_1
19	nu_1-nn_1	44	nu_4-nu_4	69	oec_4-oec_4
20	nu_4-uu_4	45	EF_2-EE_2	70	MNW_4-WNM_4
21	RR_1-RR_1	46	db_4-bb_4	71	mnu_2-nmu_2
22	WW_2-WW_2	47	FE_1-FF_1	72	MWN_2-NWM_2
23	mw_4-ww_4	48	nn_1-nn_1	73	eco_2-eco_2
24	OQ_1-OO_1	49	MM_2-WW_2	74	YXK_2-YKX_2
25	dd_4-dd_4	50	bp_4-pp_4	75	eco_2-ceo_2

Table B

First Pilot Study Stimuli, Cont.

Trial	Stimuli	Trial	Stimuli	Trial	Stimuli
76	oce_1-oce_1	85	mnu_1-mnu_1	94	$XVYK_2$-$XVYK_2$
77	ilf_1-lfi_1	86	KXY_4-XYK_4	95	$qpbd_4$-$qpbd_4$
78	fli_2-fli_2	87	unm_1-nmu_1	96	$bpdq_1$-$dqbp_1$
79	umn_4-unm_4	88	nmu_4-nmu_4	97	$pbqd_4$-$dpqb_4$
80	YXK_1-YXK_1	89	ilf_1-ilf_1	98	$qdpb_2$-$pdbq_2$
81	ifl_4-fli_4	90	NMW_1-NWM_1	99	$YKXV_2$-$KXVY_2$
82	NMW_1-NMW_1	91	$bpqd_2$-$bpqd_2$	100	$XYKV_1$-$XYKV_1$
83	KXY_4-KXY_4	92	$dpqb_1$-$dpqb_1$	101	$XYKV_4$-$XYKV_4$
84	ilf_2-fli_2	93	$YKVX_1$-$KXVY_1$	102	$XYVK_4$-$YXVK_4$

1 denotes A_1, standard alphabet.

2 denotes A_2, textured alphabet, complex (TAC).

4 denotes A_4, textured alphabet, simple (TAS), or "dotted" alphabet.

Note. Stimuli were presented in a single session for all but one subject. Trials 26-50 (inclusive) were omitted for 11 of the 14 Ss, due to time constraints.

having been learned from the school files, and that 13 of the 14 Ss completed their trials on a single day. Also, a 500 msec delay was imposed between offset of the first stimulus and onset of the second. As before, the threshold for exposure time was taken during practice trials. While the general procedure was the same, no cutoff point was used, and Ss were begun at 500 msec, with 100 msec decreases as described in the main paper. Since most of the Ss in this study were older than those in the main research, thresholds were much lower, ranging from 40 to 230 msec. The session was broken up into 25-trial segments (the last of 27), with rest breaks in between. One subject, the youngest, with the 38 on the Lee-Clark, required two days to complete all 102 trials.

The design of the experiment was a 3 X 3 (alphabets by number of letters in a stimulus), with repeated measures on both factors.

Results are shown in Table C, for latency data, and Table D, for error data. There were no significant main effects or interactions for the latency data. However, error data revealed significant main effects due to both alphabets and the number of letters in the stimulus; a Newman-Keuls analysis revealed the alphabets effect to be entirely due to the superiority of the textured alphabet to the dotted, and the number-of-letters effect to be due to the superiority of pairs to both quads and trios.

Table C

ANOVA Summary: Latencies, First Pilot Study

Source	SS	DF	MS	F
No. of letters	.084	2	.042	NSF
Alphabets	.058	2	.026	NSF
Subjects	148.887	13	11.453	
No. letters X Alphabets	.288	4	.072	NSF
No. letters X Subjects	9.697	26	.373	
Alphabets X Subjects	4.132	26	.159	
No. letters X Alphabets X Subjects	10.238	52	.197	

NSF denotes not significant ($F < 1.0$).

Note. No main effects nor interactions are significant. Stimuli were of either two, three, or four letters, and were presented successively, with a 500 msec delay between the two stimuli comprising a single trial.

Table D

Error Analyses, First Pilot Study

ANOVA Summary

Source	SS	DF	MS	F	P
No. of letters	.4661	2	.2331	10.893	$<.01$
Alphabets	.1524	2	.0762	3.528	$<.05$
Subjects	1.3955	13	.1073		
No. letters X Alphabets	.2297	4	.0574	2.506	$.05<p<.10$
No. letters X Subjects	.5557	26	.0216		
No. letters X Alphabets X Subjects	1.1888	52	.0229		

Newman-Keuls for Alphabets

	A_2	A_1	A_4
	.2305	.2906	.3129
A_2 .2305	--	.0601	.0824*
A_1 .2906		--	.0223
A_4 .3129			--

Newman-Keuls for No. Letters

	Pairs	Quads	Trios
	.1929	.3095	.3315
Pairs .1929	--	.1166*	.1386*
Quads .3095		--	.022
Trios .3315			--

* denotes significance at .05 level

A_1 denotes standard alphabet.

A_2 denotes textured alphabet, complex (TAC).

A_4 denotes textured alphabet, simple (TAS), or "dotted" alphabet.

Note. The main effect due to alphabets is entirely due to the superiority of the TAC to the TAS (i.e., of A_2 to A_4). The main effect due to letters is due to the superiority of pairs to both quads and trios. The interaction of number of letters with alphabets is almost significant at the .05 level; it is analyzed in Table E.

Interestingly, the mean errors per trial for quads was less than that for trios. This nonsignificant trend may be simply due to the limited number of stimuli and trials used for quads; only bpdq and XYKV, in various permutations of order, were used in the twelve quad trials, as no other quad sets were sufficiently similar, according to Dunn-Rankin's (1978) matrix. The interaction of alphabets with number of letters just misses significance at the .05 level; Table E shows the results of a further analysis of the interaction. The interaction is primarily due to the lower error rate with the A_2 quads than with the quads of the other two alphabets. This result suggests that textured stimuli may improve discrimination accuracy over their standard counterparts when a larger number of stimuli are strung together in a "wordlike" fashion. Further testing of this notion is obviously required.

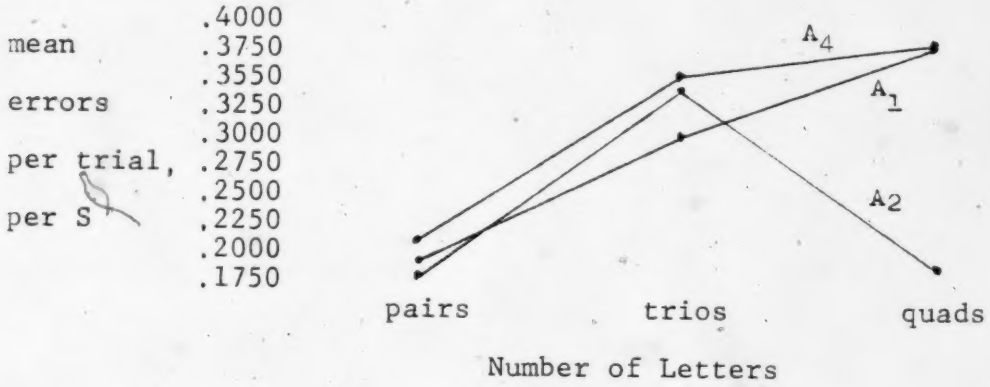
An absolute accuracy difference between simultaneous and successive discriminations is suggested in the contrast between the pilot study results and those of the major study; individual error rates in the pilot study ranged from 10.4% to 57.1%, while those in the primary study were only 1.5% for the high, and 7.6% for the low group. Timko (1977) found no such difference when kindergarten children were asked to point to a letter that was not the same as a visible (simultaneous matching) or hidden (successive matching) target letter. However, Samuels (1969), in a replication of Timko's study, found an advantage for the simultaneous mode during training,

Table E

Error Data, Alphabets by No. Letters Interaction, First Pilot Study

Mean Errors per Trial, per Subject

	A_1	A_2	A_4
pairs	.1879	.1773	.2136
trios	.3089	.3357	.35
quads	.375	.1786	.375



A_1 denotes standard alphabet

A_2 denotes textured alphabet, complex (TAC)

A_4 denotes textured alphabet, simple (TAS)

Note. It is apparent that the alphabets by number of letters interaction, which just missed the .05 level of significance (see Table D), is primarily due to the low error rate with A_2 quads, relative to quads in the other two alphabets. Only two different quad sets, bpdq and XYKV, were used in the 12 quad trials, though the order of letters was varied by trials.

but found that children trained in a successive manner performed better than the simultaneous group on a transfer task. The only procedural difference between the two studies was Samuels' exclusive use of highly similar stimuli (b/d and p/q), whereas Timko used both low (s/b) and high (b/d) similarity conditions. As all of the stimuli in this pilot study were highly similar, and those of the principal study were quite dissimilar in the first two sessions, the advantage of the textured alphabet with the error data in the pilot might indicate, in agreement with Samuels (1969), that simultaneous discriminations are easier than successive, when difficulty (i.e., stimulus similarity) is high. Such an interpretation must be made with caution since the pilot study involved only "reading disabled" children, whose error percentages might well have been higher in a paradigm identical to that of the principal research reported above. The visual memory deficit hypothesis of reading disability (see discussion) would also predict poorer performance for reading disabled subjects on a successive than on a simultaneous discrimination task. Certainly a direct test of simultaneous versus successive modes with both groups of subjects, and all three of the alphabets under study is required before any of these issues can move towards satisfactory resolution.

Appendix C: Second Pilot Study

In late November and early December of 1978, a second pilot study was conducted with cerebral-palsied children, ages five to fourteen years. As Clement's latency advantage (Note 1) for the dotted (TAS) alphabet over the standard was obtained with c.p. subjects in a simultaneous mode, and as the first pilot study revealed an advantage of the TAC over the TAS in the error data in a successive mode, it was desirable to test all three alphabets against one another in a successive mode with c.p. Ss. It is at least possible that the various alphabets may interact with the specific disability (or lack thereof) of the subject sample, as well as with presentation mode.

Of the twenty-one subjects who were originally selected for the study (all from the same school hospital in a large western Canadian city), seventeen completed the entire experiment. Of these 17, eight were boys. Four subjects were lost due to absences, an unexpected surgery, and one case in which the S apparently could not comprehend the instructions. All of the children have been diagnosed as cerebral-palsied; a conscious effort was made to include those with minimal athetoid involvement, because of the nature of the task (pushing buttons, and holding the head relatively stationary for each trial). Four of the Ss required wooden blocks taped to the buttons in order to respond with any consistency. Of these four, two used only

their left hand. Three of the remaining 13 children used only their right hand, and two used only their left hand.

Stimuli were simple words of two, three, and four letters. The root word for each trial was selected from the Dolch (1941) "basic sight vocabulary" of 220 words. Words appearing in each alphabet were equated for frequency with the aid of the American Heritage Word Frequency Book (1971). There were 72 trials per subject; word-stimuli by trial are presented in Table F. Stimuli were randomized across both sessions, and there was an equal number of "sames" and "differences" in each alphabet. Mounting of stimuli and visual angles subtended followed exactly the details given in the body of this paper. All stimuli were lower case.

Subjects generally had two sessions of roughly 45 minutes each, with 36 trials in each session. The first session was preceeded by giving of instructions and by practice trials. Ss continued to see practice trials until a criterion of three successive correct responses was reached. Depending on the number of days elapsed between sessions (irregularities were imposed by subjects' therapy schedules and absences), instructions were reviewed before the second session in greater or lesser detail. Practice to the same criterion also preceeded the second session; the same practice stimuli (twelve trials) were used throughout. These practice words included the letters "c," "q," and "z," which did not appear in any of the 144 stimulus words in the

Table F

Second Pilot Study Stimuli

Trial	Stimuli	Trial	Stimuli	Trial	Stimuli
1	now_4-new_4	25	$best_2$-$best_2$	49	bit_4-bet_4
2	get_4-got_4	26	bet_4-bet_4	50	bag_1-bag_1
3	$were_4$-$wear_4$	27	who_1-who_1	51	tap_4-tap_4
4	and_4-and_4	28	axe_2-axe_2	52	dry_2-red_2
5	$keep_4$-$keep_4$	29	sea_4-sea_4	53	$rest_2$-$best_2$
6	dip_2-did_2	30	bag_1-big_1	54	in_1-in_1
7	$hush_1$-$hush_1$	31	$bean_1$-$been_1$	55	or_2-to_2
8	$ball_1$-$ball_1$	32	ate_1-ate_1	56	any_4-and_4
9	$were_4$-$were_4$	33	$then_1$-$thin_1$	57	$flap_2$-$flat_2$
10	tag_4-get_4	34	$sand_2$-$said_2$	58	pot_1-top_1
11	$tall_1$-$ball_1$	35	ton_4-ton_4	59	$said_2$-$said_2$
12	who_1-how_1	36	ton_4-not_4	60	jam_2-ham_2
13	or_2-or_2	37	saw_2-saw_2	61	tap_4-put_4
14	too_2-two_2	38	$only_1$-$only_1$	62	axe_2-ask_2
15	see_4-sea_4	39	tab_2-bat_2	63	got_4-got_4
16	$ugly_1$-$only_1$	40	$hair_4$-$here_4$	64	$with_4$-$with_4$
17	was_2-saw_2	41	is_1-in_1	65	$been_1$-$been_1$
18	$then_1$-$then_1$	42	jam_2-jam_2	66	tab_2-tab_2
19	yes_1-yes_1	43	say_1-yes_1	67	$here_4$-$here_4$
20	two_2-two_2	44	$give_2$-$give_2$	68	now_4-now_4
21	red_2-red_2	45	$flap_2$-$flap_2$	69	ten_1-ten_1
22	$peek_4$-$keep_4$	46	dip_2-dip_2	70	$wish_4$-$with_4$
23	$give_2$-$gave_2$	47	pot_1-pot_1	71	tag_4-tag_4
24	$hush_1$-$wish_1$	48	net_1-ten_1	72	ate_1-are_1

1 denotes A_1, the standard alphabet.

2 denotes A_2, the textured alphabet, complex (TAC).

3 denotes A_3, the textured alphabet, simple (TAS).

"real" trials. Of course, some of the practice letters did reappear in the course of the actual experiment, though none of the practice words reappeared.

Thresholds for stimulus exposure were not taken, as all exposures for all Ss were set at 40 msec in order to allow only a single eye fixation. Viewing was monocular, with S using his or her preferred eye. Eye preference and hand preference were assumed to be the same, except in cases of obvious visual motor problems in a given eye. Most Ss were confined to a wheelchair; height adjustments in the entire apparatus were made to suit the needs of each subject, so that S's comfort in performing the task was maximized.

Stimulus presentation was successive, as in Appendix B, with a 500 msec delay between offset of the first stimulus and onset of the second. The statistical design was a one-way, repeated measures ANOVA.

Results for all 17 Ss are given in Table G. While variation between subjects was quite high in both latency and error data, the main effect of alphabets was negligible in both cases. Before the study was completed, it was decided to examine separately the data for Ss whose accuracy in the "same-different" task was significantly better than chance. A chi-square test revealed that 45 or more correct responses in the 72 trials yielded a performance significantly better than chance at the .05 level. Using

Table G

ANOVA Summaries, Second Pilot Study, All Ss

Latencies

Source	SS	DF	MS	F	P
Subjects	28,377.15	16	1773.572	25.65	<.005
Alphabets	26.35	2	13.175	NSF	
Subjects X Alphabets	2,212.31	32	69.135		

Errors

Source	SS	DF	MS	F	P
Subjects	706.7056	16	44.1691	7.038	<.005
Alphabets	18.5095	2	9.2548	1.475	.10<p<.25
Subjects X Alphabets	200.8239	32	6.2757		

NSF denotes not significant ($F < 1.0$).

Note. There is no main effect due to alphabets in either set of data. All 17 Ss were included in this analysis; Ss were cerebral-palsied youngsters, aged five to fourteen years.

this criterion (62.5% accuracy), only nine of the 17 Ss were included in the second analysis.

Table G gives the results of this analysis. As before, the latency data reveal no effect of alphabets. However, the main effect due to alphabets in the error data just misses significance at the .05 level. Simple inspection of the error totals for the three alphabets (41 for the standard alphabet, 40 for the TAC, and 59 for the TAS) reveals that this effect is entirely due to the higher error rate with the A_4, dotted (TAS) backgrounds than with either of the other two alphabets, which obviously do not differ from one another.

It is apparent that error rates in this study were too high. The low exposure time, low reading level of many of the children, and confusable nature of the word-stimuli all probably contributed to the high error rates. Only five of the 17 Ss made fewer than 20 errors; two of these five made only one error apiece. The wide range of ages included in the study also contributed to the high variability between subjects.

Nonetheless, the significant ($p<.10$) advantage of the textured (TAC) and standard alphabets over the TAS alphabet in the error data (second analysis) is the second indication in this body of research that the TAS may be inferior to the TAC. This further obscures interpretation of Clement's (Note 1) data, and points all the more urgently towards

Table H

ANOVA Summaries, Second Pilot Study, Non-Chance Ss

Latencies

Source	SS	DF	MS	F	P
Subjects	13,365.42	8	1670.678	42.73	$<.005$
Alphabets	81.8	2	40.9	1.05	$.25<p$
Subjects X Alphabets	625.61	16	39.1		

Errors

Source	SS	DF	MS	F	P
Subjects	297.4073	8	37.1759	10.04	$<.005$
Alphabets	25.4073	2	12.7037	3.43	$.05<p<.10$
Subjects X Alphabets	59.2594	16	3.7037		

Note. The alphabets main effect in the error data just misses significance at the .05 level. Inspection of the error totals for the three alphabets (41 for standard alphabet, 40 for TAC, 59 for TAS) reveals that this effect is due solely to the greater error rate with the TAS than with either of the other two alphabets. The nine Ss included here had 45 or more correct responses, which was significantly better than chance at the .05 level.

methodological changes outlined in the main paper. With this further indication of the superiority of the TAC to the TAS, however, simplification of the TAC backgrounds may not be warranted. As noted in the discussion of the main paper, a shift to textured alphabet research of a more pedagogical, classroom reading type would be appropriate at this time.

Appendix D

Standard Deviations for Error and Latency Data, Main Study, All Trials

Table I: Trials 1-58

Latencies		Errors	
Highs (overall),	s = .5915	Highs (overall),	s = 2.0164
Highs, A_1,	s = .2505	Highs, A_1,	s = .6112
Highs, A_2,	s = .2382	Highs, A_2,	s = .7559
Highs, A_3,	s = .306	Highs, A_3,	s = 1.4064
Lows (overall),	s = 1.0142	Lows (overall),	s = 4.6154
Lows, A_1,	s = .7984	Lows, A_1,	s = 1.6723
Lows, A_2,	s = .7059	Lows, A_2,	s = 1.6458
Lows, A_3	s = .9681	Lows, A_3,	s = 2.9023

Table J: Trials 59-66

Latencies		Errors	
Highs (overall),	s = .6905	Highs (overall),	s = 1.2225
Highs, A_1,	s = .6091	Highs, A_1,	s = .9973
Highs, A_2,	s = .8078	Highs, A_2,	s = .7596
Lows (overall),	s = 1.0351	Lows (overall),	s = .8771
Lows, A_1,	s = 1.1117	Lows, A_1,	s = .7703
Lows, A_2,	s = 1.0326	Lows, A_2,	s = .8644

A_1 denotes standard alphabet.

A_2 denotes textured alphabet, complex (TAC).

A_3 denotes A_2 textures without letters.

s denotes standard deviation.

"Highs" denotes high reading-readiness group (n = 14).

"Lows" denotes low reading-readiness group (n = 14).

Note. All standard deviations are calculated on the basis of

mean latency per S per alphabet, or total errors per S per alphabet. Variability of the low group was at least twice that of the high throughout the first 58 trials; in the last eight trials, the lows showed greater variability than the highs in the latency data, but were less variable than the highs in the error data. This is undoubtedly due to a floor performance effect in the low group, whose error rates clustered at 50% for the last eight trials.

Appendix E: Letter-By-Letter Analyses, Main Study

Table K gives a ranking of letters, within each alphabet, by the mean latency obtained per letter. Ties in rank are due to the occurrence of two different letters on each of the "different" trials in trials 1-42. Such ties do not occur in trials 43-58, since the lower-case letters used in this set of trials were used more than once each, with the exception of c_2 and e_1. Trials 59-66 are not included in these analyses.

In general, the table gives an indication that fairly dramatic improvements in relative (rank-ordered) latency may occasionally occur when a standard letter is matched with a textured background. The letter "K" is an excellent example of such a shift: it moves from rank 16.5 in the A_1 to rank 2.0 in the A_2, even though the "K" texture by itself is ranked only 21.0 in the A_3. Whether or not the number of such shifts is greater than chance is not clear at present. In any case, Table K should have its greatest value as a reference for any future attempts to modify the TAC by switching the backgrounds of certain letters. Latency rankings based on the altered TAC stimuli could be compared with those in Table K as one means of determining whether or not the changes actually improve the performance of the altered stimuli.

Table L gives a grouping of letters, within each

alphabet, by the mean number of errors obtained per trial, per letter. Letter-by-letter ranking was impractical, as large numbers of letters had the same error rates, but a general picture of high and low error-producing stimuli still emerges. As noted in the table, data from any two letters which appeared in the same trial are necessarily confounded.

It is apparent from the table that the highest error rates were produced with the lower-case stimuli of trials 43-58, a result already pointed out by Table 14 in the main paper. It is not clear why such a high error rate was obtained with the I_2 stimulus, particularly since stimuli which might be expected to be confused with I_2, such as F_2, L_2, and T_2 score relatively low in error rate. Particular attention should perhaps be paid to modifying the background, and/or the letter-to-background matchup, of the I_2 stimulus.

Table K

Letter-By-Letter Analysis of Latency Data, with Letters Ranked by Mean Latency per Letter, Trials 1-58 Only

A_1				A_2				A_3			
Rank	Letter	Latency	S	Rank	Letter	Latency	S	Rank	Letter	Latency	S
1.0	A	1.486	.859	1.0	A	1.312	.669	1.5	A	1.756	.823
2.0	Q	1.515	.62	2.0	K	1.473	.673	1.5	L	1.756	.823
3.0	Y	1.545	.672	3.0	F	1.565	.611	3.0	V	1.776	.943
4.0	c	1.555	.831	4.0	Z	1.568	.614	4.5	F	1.905	.763
5.5	G	1.557	.697	5.5	R	1.633	.649	4.5	Y	1.905	.763
5.5	T	1.557	.697	5.5	X	1.633	.649	6.0	U	1.91	1.004
7.5	0	1.578	.632	7.0	p	1.655	.825	7.5	0	1.912	1.125
7.5	U	1.578	.632	8.0	b	1.688	.769	7.5	X	1.912	1.125
9.0	b	1.591	.89	9.5	W	1.702	.64	9.5	T	1.923	1.115
10.0	p	1.597	.907	9.5	Q	1.702	.64	9.5	Q	1.923	1.115
11.5	M	1.604	.703	11.0	e	1.708	.854	11.0	J	1.943	.787
11.5	S	1.604	.703	12.5	J	1.717	.963	12.5	N	2.04	.859
13.0	I	1.616	.586	12.5	Y	1.717	.963	12.5	S	2.04	.859
14.0	R	1.618	.586	14.0	d	1.741	.893	14.0	M	2.13	1.099
15.0	V	1.634	.595	15.0	V	1.766	.804	15.5	G	2.191	1.012
16.5	K	1.66	.765	16.5	H	1.782	.951	15.5	Z	2.191	1.012
16.5	Z	1.66	.765	16.5	U	1.782	.951	17.5	I	2.198	.739
18.0	d	1.665	.783	18.0	G	1.818	.631	17.5	W	2.198	.739
19.0	e	1.691	.912	19.5	N	1.84	.746	19.0	R	2.26	1.092
20.0	X	1.765	.852	19.5	S	1.84	.746	20.0	H	2.32	1.002
21.0	F	1.769	.921	21.0	c	1.863	.628	21.0	K	2.337	1.117
22.5	J	1.851	.891	22.5	M	1.896	.723				
22.5	N	1.851	.891	22.5	T	1.896	.723				

Table K (continued)

A_1				A_2				A_3			
Rank	Letter	Latency	S	Rank	Letter	Latency	S	Rank	Letter	Latency	S
24.0	H	1.865	.735	24.0	I	2.097	.811				
25.5	L	1.958	1.046	25.5	L	2.354	1.03				
25.5	W	1.958	1.046	25.5	O	2.354	1.03				

A_1 denotes standard alphabet.

A_2 denotes textured alphabet, complex (TAC).

A_3 denotes A_2 textures without letters.

s denotes standard deviation.

Note. Any two letters tied in rank appeared in the same trial; their data are therefore confounded. All upper-case letters not tied in rank with another letter appeared with themselves in a "same" trial. Most lower-case letters appeared in more than one trial: b_2, c_1, and e_2 each appeared in two trials, while b_1, d_1, d_2, p_1, and p_2 each appeared in three trials. c_2 and e_1 appeared in only one trial each.

Table L

Letter-By-Letter Analysis of Error Data, Trials 1-58 Only

A_1		A_2		A_3	
$\bar{X}_e$	Letters	$\bar{X}_e$	Letters	$\bar{X}_e$	Letters
0	A,M,O,S,U,V,Q	0	A,G,J,K,R,V, X,Y	.0357	A,L
.0357	F,G,H,I,K,L,R, T,W,X,Y,Z	.0357	H,L,M,N,O,S, T,U,Z	.0714	T,Q
.0595	p	.0714	F,p,W,Q	.1071	F,O,X,Y
.0714	b,J,N	.1071	c,e	.1429	G,N,R,S,Z
.0833	d	.125	b	.1786	H,I,J,U,V,W
.1429	c	.1786	d	.2143	M
.25	e	.25	I	.3214	K

A_1 denotes standard alphabet.

A_2 denotes textured alphabet, complex (TAC).

A_3 denotes A_2 textures without letters.

$\bar{X}_e$ denotes mean errors per trial, per letter.

Note. Any two letters which appeared in the same trial (see Table 7, main paper) will have the same mean error rate due to confounding of the two stimuli. Most lower-case letters appeared in more than one trial: each of b_2, c_1, and e_2 appeared in two trials, while each of b_1, d_1, d_2, p_1, and p_2 appeared in three trials. c_2 and e_1 appeared in only one trial each. Letters b,c,d,e, and p did not appear in the A_3 condition.